10th Annual Systems Engineering Conference
"Focusing on Improving Performance of Defense Systems Programs"

San Diego, CA
22-25 October 2007

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Agenda

Tuesday, 23 October 2007

Keynote Addresses:

- *Hon James Finley,* Deputy Under Secretary of Defense, Acquisition and Technology
- *Hon Charles McQueary,* Director, Operational Test and Evaluation

Plenary Session: Executive Panel:

- *Mr. Mark Schaeffer,* Director, Office of Under Secretary of Defense of Acquisition, Technology and Logistics; Director, Systems and Software Engineering

Panelists:

- *Mr. Terry Jaggers,* SAF/AQR – Science, Technology, and Engineering
- *Mr. Carl Siel,* Chief Engineer, Office of the Assistant Secretary of the Navy Research, Development and Acquisition
- *Mr. Doug Wiltsie,* HQDA, OASA (ALT)

Track 1

- "Update: OSD Systems Engineering Revitalization Efforts," Col Richard Hoeferkamp, USAF
- "The Effectiveness of Systems Engineering: On Federal (DoD) System Development Programs", Mr. Al Mink, SRA International
- "Tools and Resources to Enable Systems Engineering Improvement," Mr. Michael Kutch, SPAWAR Systems Center Charleston
- "Sound Systems Engineering Assures Proper/Early Producibility", Dr. Thomas Christian, Aeronautical Systems Center
- "Realization of Systems Engineering For the Future", Ms. Karen Bausman, AF Center for Systems Engineering

Track 2

- "Developmental Test & Evaluation Policy Vectors", Ms. Darlene Mosser-Kerner OUSD (AT&L)
- "Test Strategy Done Early Drives Test Planning and Successful Testing", Mr. William Lyders,ASSETT, Inc.
- "Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation", Mr. Joseph Tribble, AVW "Implementing a Systems Engineering Risk Program in a Sustainment Environment", Mr. James Miller, USAF
- "Joint Safety Review Process Study", Ms. Paige Ripini, Booz Allen Hamilton

Track 3

- "DoD Systemic Root Cause Analysis", Mr. Dave Castellano, OUSD (AT&L)
- "Applying Systems Engineering During Pre-Acquisition Activities", Lt Col Mark Wilson, USAF
- "Reforming the DoD Acquisition Process—A Systems Engineering Approach", Mr. Stephan Ward, U.S. Air Force
- "The Effectiveness of Systems Engineering: On Federal System Development Programs", Mr. Alan Mink, SRA International

Track 4

- "Environment, Safety, and Occupational Health (ESOH)—Design Considerations to Support Sustainability and Readiness", Ms. Patricia Huheey, ODUSD (I&E)
- "Real-Time Diagnostics for High Availability Systems", Mr. Edward Beck, Computer Sciences Corporation
- "Sparing Satellites Comparative Strategies of On-orbit & In-factory Storage", Mr. James Mazzei, The Aerospace Corporation

Track 5

- "Acquisition M&S Master Plan Implementation Status", Mr. Michael Truelove, SAIC
- "Establish M&S-Related Guidelines for Solicitations, Source Selections, and Contracting", Mr. Michael Truelove, SAIC
- "Modeling and Simulation Resource Reuse Business Model", Mr. Dennis Shea, Center for Naval Analyses

- “Modeling and Simulation Support Plan”, Mr. David Henry, Lockheed Martin
- “Modeling and Simulation Education for the Acquisition/T&E Workforce: Requirements Analysis”, Mr. David Olwell, NPS

Track 6

- “The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen)”, Mr. David Synder, The MITRE Corp.
- “Complex Systems of Systems: The Dual Challenge”, Mr. Phillip Boxer, Software Engineering Institute
- “Systems Engineering in the Cognitive and Social Domains of Net Centric Operations”, Dr. Abe Meilich, Lockheed Martin
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Track 7

- “Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines”, Mr. Raymond Jorgensen, Rockwell Collins
- “NAVAIR Systems Engineering Revitalization”, Mr. Michael Gaydar, Department of Navy, NAVAIR
- “Integrating Engineering Project Management and Product Development Processes”, Mr. Raymond Jorgensen, Rockwell Collins
- “Engineering for System Assurance—Legacy, Life Cycle, Leadership”, Mr. Paul Croll, Computer Sciences Corporation

Track 8

- “DoD Software Engineering and System Assurance”, Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering
- “The Integrated Software and Systems Engineering Curriculum Project: Creating a Reference Curriculum for Graduate Software Engineering Education”, Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software
- “Requirements for a Chief Software Engineer in a DoD Acquisition Agency”, Mr. Al Florence, The MITRE Corporation
- “Developing an Integrated Process Methodology for Interim Software Releases”, Mr. Tim Woods, Southern Methodist University

Wednesday, 24 October 2007
Track 1

- “Change Management of UML-Based Systems Engineering Artefacts”, Mr. David Price, Eurostep
- “A Day in the Life of a Verification Requirement”, Mr. Stephen Scukanec, Northrop Grumman Corporation
- “How to Measurably Improve Your Requirements”, Mr. Timothy Olson, Lean, Solutions Institute, Inc.
- “Case Studies: A Common Language Between Engineers and Managers”, Capt DeWitt Latimer, USAF
- “A Strategy for Improved System Assurance”, Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- “Discussion of the U.S. Army RDECOM APS Objective Trade Study”, Mr. Frank Salvatore, High Performance Technologies, Inc.
- “Program Support Review Deep Dive”, Mr. Peter Nolte, OUSD/SSE

Track 2

- “An Update on the DT&E Committee’s Recommended Policy Changes to DoD 5000”, Col Richard Stuckey,USAF,OUSD (AT&L)/SSE/ DT&E
- “System Test and Evaluation in the DARPA Immune Building Demonstration Program”, Mr. Mark Saxon,Battelle
- “ Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise”, Ms. Shala Malone,Navy Program Executive Office Integrated Warfare
- “Joint Mission Environment Test Capability (JMETC)”, Mr. Richard Lockhart, Test Resource Management Center
- “Testing Concept of Operations in DoD’s Net Centric Environment”, Mr. Steve Reeder, South Carolina
- Research Authority (SCRA
- “Do it right, do it early; Do it early, do it right”—Considerations for the Early Stages of Concept, System, and Systems of-Systems Definition”, Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)
- “Applications of Systems Engineering to Pre-Milestone A Projects”, Ms. Lori Zipes,Naval Surface Warfare Center PC
- “Systems Engineering in a Systems of Systems Environment - Defense Update”, Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- “ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project”, Mr. G. Richard Thompson, JHU/APL

Track 3

- “Systems Engineering Plan Preparation Guide Update”, Mr. Chester Bracuto, OSD/AT&L/A&T/SSE/ED
- “ Toward a Unified Systems Engineering Plan”, Mr. Robert Scheurer, Boeing Integrated Defense Systems
- “Integrating Risk & Knowledge Management”, Mr. David Lengyel, NASA
- “Systems Engineering and Program Management—How Different are They?”, Ms. Lori Zipes, Naval Surface Warfare Center PC
- “Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems”, Mr. Michael Harper, SPAWAR Systems Center Charleston
- “ The Joint Partnership Between Program Management and Systems Engineering”, Mr. Samuel Son, The Boeing Company
- “Lockheed Martin Aeronautics Company Approach to Solving Systemic Development Program Issues”, Mr. John Weaver, Lockheed Martin Aeronautics Company
- “Airborne Signals Intelligence Payload (ASIP) Program Integrated Risk Management”, Mr. Danial Bolek, USAF
- “Improvements to the Risk Management Process”, Mr. Doug Atkinson, USAF
- “Integrated Risk and Earned Value Management”, Mr. Paul Davis, Northrop Grumman
- “Application of Risk Management Practices to NNSA Tritium Readiness Subprogram”,Mr. Sham Shete, Washington Savannah River Co.

Track 4

- “Defining Lean Service and Maintenance Processes”, Mr. Timothy Olson, Lean Solutions Institute, Inc.
- “Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard”, Mr. Patrick Cumby, VectorCSP, L

"Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ships", Mr. Michael Mahon, Lockheed Martin

- "Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering)," Mr. Steven Head, Boeing
- "Aging Aircraft Sustainment with Non-Standard Engineering", Ms. Kendal Hinton, Georgia Tech Research Institute
- "Maintaining System Viability for the Long Term", Mr. Peter Henry, BAE Systems Land and Armament
- "C-17 Program Applies Systems Engineering to a Large Improvement Project", Mr. Brent Theodore,The Boeing Company

Track 5

- *"Advancing the FEDEP for Simulation Based Acquisition*", Dr. Katherine Morse, SAIC
- "Acquisition M&S Community Sponsored M&S Project: Standardized Documentation for Verification, Validation, and Accreditation", Mr. Kevin Charlow, *(paper)* *(slides)* Space and Naval Warfare Systems Center Charleston
- "A Methodology for Assessing & Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations", Dr. James Elele, U.S. Navy
- "Experiences in Applying SysML to Develop Interoperable Torpedo Modeling and Simulation Components", Mr. Thomas Haley, Naval Undersea Warfare Center
- "Unifying Systems Engineering Simulations", Mr. Ryan O'Grady, Cybernet Systems Corporation
- "Information Modeling for Systems Integration", Ms. Claudia Rose,BBII
- "Simulation Supported Decision Making", (slides1) (slides 2) *Mr. Gene Allen*, MSC Software Corporation

Track 6

- "Achieving Agility in Cyberspace", Mr. Phillip Boxer, Software Engineering Institute
- "Application of Autonomic Agents for Global Information Grid", Mr. David Cox, University of Arizona
- "Architecture-Based Concept Evaluation in Support of JCIDS", Dr. David Jacques,Air Force Institute of Technology
- "System of Systems Implications for Operational Test", Dr. John Colombi, Air Force Institute of Technology
- "Case Study: Net Centric Mission Thread Modeling and Analysis", Dr. Prem Jain, MITRE
- "Quantitative Comparison of Alternative Designs for a JC3M System", Mr. Gregory Miller, Naval Postgraduate School
- "Advanced Net Centric Simulation for Aerospace Command and Control", Ms. Kimberly Kendall, 753d ELSG/NEM, ESC, USAF

Track 7

- "CMMI—Next Steps", Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA
- "CMMI Instructional Challenges to Systems Engineers in Small Settings", Dr. Mary Anne Herndon, Transdyne Corporation
  "FISMA Operational Controls and Their Relationship to Process Maturity", Ms. Rhonda Henning, Harris Corporation
- "Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston", Mr. Michael Kutch, SPAWAR Systems Center Charleston
- "CMMI for Services: Re-Introducing the CMMI for Services Constellation", Mr. Craig Hollenbach, Northrop Grumman Corporation
- "How to Paint a Room: The Role of Specs & Standards in SE", Mr. Robert Kuhnen, USAF
- "Continuous Improvement at the Organization, Team, and Individual Levels —Lessons Learned Integrating CMM,TSP, and PSP and Why All Three are Needed", Mr. Girish Seshagiri,Advanced Information Services, Inc
- "Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program", Ms. Jennifer Malone, EG&G
- "Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program", Mr. Ricky Milnarik, Electric Boat Corporation
- "The Safety of Unmanned Systems: The Process Used to Develop Safety Precepts for Unmanned Systems", Mr. Mike Demmick, NOSSA

Track 8

- "Defining Software Component Specifications: An Open Approach", Mr. Kenneth Klein,Computer Sciences Corporation
- "System Engineering and Software Exception Handling (SEH)", Mr. Herbert Hecht, SoHaR Incorporated
- "A Convergence of Technologies for Better Software NOW!", Ms. Dorothy Acton, Lockheed Martin IS&GS
- "Identifying Acquisition Patterns of Failure Using System Archetypes", Mr. William Novak, Software Engineering Institute
- *"Revitalizing Education and Training in Systems Engineering", Dr. Don Gelosh*, Department of Defense, OSD(AT&L)/SSE/ED
- "Customer-Driven, Partnership-Based Systems Engineering Education and Training", Mr. Jerrell Stracener, Southern Methodist University
- "Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula", (paper) (slide) *Dr. David Olwell*, Naval Postgraduate School

Thursday, 25 October 2007

Track 1

- "USAF Type Certification of Commercial Derivative Aircraft", Mr. Thomas Morgan, USAF
- "Global Positioning System Case Study", Mr. Randall Bullard, Air Force Center for Systems Engineering

Track 2

- "Implementing the Technology Maturity Vector", Mr. Joseph Terlizzese, Systems Engineering Support Office
- "Technology Readiness Assessments; Milestone B Certification Requirement for Technologies to be Demonstrated in a Relevant Environment", Dr. Jay Mandelbaum, Institute for Defense Analyses
- "Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen)", Mr. Jerry Friedman,

The MITRE Corporation

- “Sensor Resource Allocation as a Driver in System Concept Development”, Mr. Ravi Moorthy, Lockheed Martin MS2

Track 3

- “Managing Requirements to Manage Scope in the Case of MUOS”, Ms. Christy Howard, Maxim Systems, Inc.
- “Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs”, Mr. Francis Sisti, Aerospace Corporation
- “C-17 Systems Engineering Process to Prioritize Material Improvement Program (MIP) Projects”, Mr. Thomas Condron, USAF (516 AESG/ASC)
- “How to Talk to a Program Manager”, Dr. John Mishler, Software Engineering Institute
- “U.S. Department of Defense (DoD) Approach to Best Practices: Building Evidence for Practice Selection Based on Real Experiences”, Dr. Forrest Shull, Fraunhofer Center Maryland

Track 4

- “Strategic Focus: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE)”, Dr. Danny Reed, Institute for Defense Analyses
- “Progress Toward an Empirical Relationships Between Reliability Investments and Life-Cycle Support Cost”, Dr. James Forbes, LMI
- “Innovation Strategies for Affordable Readiness”, Mr. Tom Choinski, Naval Undersea Warfare Center
- “Implementing a Systems Engineering Risk Program in a Sustainment Environment”, Mr. James Miller, USAF
- “Asset-Based PBL for Navy Warships – A case study for LCA Class Ships”, Mike Mahon
- “The Deployment Readiness Service: The Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment”, Mr. George Dalton, USAF

Track 5

- “Aircraft Flight Simulator Acceptance Criteria”, Mr. Dean Carico, NAWCAD PAX
- “Computer Modeling to Solve Problems with the T-38 Propulsion Modernization Program”, Mr. Randall Wimer, USAF – FVB
- “Efficacy of Modeling & Simulation in Defense Life Cycle Engineering”, Mr. Donald Cox, Raytheon Missile Systems
- “Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard”, Mr. Patrick Cumby, Vector CSP, LLC
- “Generic Sensor Model”, Dr. Stanley Hack, Lockheed Martin MS-2
- “Event Timeline Analysis in Multi Mission Scenarios with System Simulation Models”, Mr. Ravi Moorthy, Lockheed Martin MS2

Track 6

- “Testing Concept of Operations in DoD’s Net Centric Environment”, Mr. Steve Reeder, South Carolina Research Authority (SCRA)
- “Agile Governance for SOA-Based Military Systems of Systems”, Mr. Robert Beck, Villanova University
- “Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA”, Mr. Tim Greer, Lockheed Martin Corporation

Track 7

- “The DoD’s Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow’s Warfighter and Mission Readiness”, Dr. Carole LeBlanc, Office of the Deputy Under Secretary of Defense
- *“Safe-Escape Analysis System Safety Engineering Study*”, (paper) (slide) *Mr. David Hall,* SURVICE Engineering Company

Track 8

- “Development of Systems Engineers in the Sensors & SONAR Systems Department”, Mr. Lawrence Lazar,Naval Undersea Warfare Center
- “Systems Engineering and the Art of Seeing”, Dr. Robert Monson, Lockheed Martin Corporation
- “Understanding Social Networks-A Key Requirement for System Engineers”, Mr. Karl Selke, Systems Engineering Analyst, Evidence Based Research, Inc.

NDIA
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PROMOTING NATIONAL SECURITY SINCE 1919

10th ANNUAL SYSTEMS ENGINEERING CONFERENCE

HYATT REGENCY MISSION BAY → SAN DIEGO, CA

OCT. 22 - 25, 2007

WWW.NDIA.ORG/MEETINGS/8870

Event # 8870

Conference Agenda {At A Glance}

Sunday, October 21, 2007

5:00 pm - 7:00 pm	Registration for Tutorials and General Conference *(Tutorials are an additional $225.00 registration fee)*

Monday, October 22, 2007

7:00 am - 6:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast for Tutorial Attendees ONLY *(Tutorials are an additional $225.00 registration fee)*
8:00 am - 11:45 am	Tutorial Tracks *(Please refer to pages 4-5 for Tutorial schedule)*
12:00 pm - 1:00 pm	Lunch for Tutorial Attendees ONLY
1:00 pm - 5:00 pm	Tutorial Tracks Continued
5:00 pm - 6:00 pm	Reception in the Regatta Pavilion (Open to All Participants)

Tuesday, October 23, 2007

7:15 am - 6:30 pm	Registration
7:15 am - 8:15 am	Continental Breakfast
8:15 am - 8:30 am	Introductions & Opening Remarks: *Mr. Sam Campagna, Director, Operations, NDIA* *Mr. Bob Rassa, Director, Systems Supportability, Raytheon, Chair, Systems Engineering Division, NDIA*
8:30 am - 9:45 am	Keynote Addresses: *HON James Finley, Deputy Under Secretary of Defense, Acquisiton & Technology* *HON Charles McQueary, Director, Operational Test & Evaluation*
9:45 am - 10:00 am	Break

10:00 am - 12:00 pm	Plenary Session: Executive Panel Moderator: *Mr. Mark Schaeffer, Director, Office of Under Secretary of Defense for Acquisition, Technology and Logistics; Director, Systems and Software Engineering* Panelists: *Mr. Terry Jaggers, SAF/AQR - Science, Technology, and Engineering* *Mr. Carl Siel, Chief Engineer, Office of the Assistant Secretary of the Navy Research, Development and Acquisition* *Mr. Doug Wiltsie, HQDA, OASA (ALT)*
12:00 pm - 1:30 pm	Luncheon with Speaker in the Regatta Pavilion *Mr. Mike Kern, Senior Systems Engineer, OASD (NII)*
1:30 pm - 5:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
5:00 pm - 6:30 pm	Reception in the Regatta Pavilion

Wednesday, October 24, 2007

7:00 am - 5:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:00 am - 12:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
12:00 pm - 1:30 pm	Awards Luncheon in the Regatta Pavilion
1:30 pm - 5:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*

Thursday, October 25, 2007

7:00 am - 3:00 pm	Registration
7:00 am - 8:00 am	Continental Breakfast
8:00 am - 12:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
12:00 pm - 1:00 pm	Luncheon in the Regatta Pavilion
1:00 pm - 3:00 pm	Concurrent Sessions *(Please refer to pages 6-10 for session schedule)*
3:00 pm	Conference Adjourns

Tutorial Sessions - Monday, October 22, 2007

7:00 am Registration & Continental Breakfast

Break

Room	8:00 am - 9:45 am		10:15 am - 11:45 am	
Bayview A	Track 1 Tutorial Session 1A1	5305 - Are we Ready for CMMI®? If not, Let's Fix Ourselves *Mr. Al Florence, The MITRE Corporation*	Track 1 Tutorial Session 1B1	5305 - Are we Ready for CMMI®? If not, Let's Fix Ourselves (Cont'd) *Mr. Al Florence, The MITRE Corporation*
Bayview B	Track 2 Tutorial Session 1A2	5454 - Cost As an Independent Variable and Trade Studies *Mr. Ed Casy, Raytheon Missile Systems*	Track 2 Tutorial Session 1B2	5454 - Cost As an Independent Variable and Trade Studies (Cont'd) *Mr. Ed Casy, Raytheon Missile Systems*
Bayview C	Track 3 Tutorial Session 1A3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices *Mr. Gary Langford, The Naval Postgraduate School*	Track 3 Tutorial Session 1B3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
Mission I	Track 4 Tutorial Session 1A4	5498 - System Verification Organization *Mr. Jeffrey Grady, JOG System Engineering, Inc.*	Track 4 Tutorial Session 1B4	5498 - System Verification Organization (Cont'd) *Mr. Jeffrey Grady, JOG System Engineering, Inc.*
Mission II	Track 5 Tutorial Session 1A5		Track 5 Tutorial Session 1B5	
Mission III	Track 6 Tutorial Session 1A6	5542 - Best-In-Class Early Defect Detection and Defect Prevention *Mr. Timothy Olson, Lean Solutions Institute, Inc.*	Track 6 Tutorial Session 1B6	5542 - Best-In-Class Early Defect Detection and Defect Prevention (Cont'd) *Mr. Timothy Olson, Lean Solutions Institute, Inc.*
Palm I	Track 7 Tutorial Session 1A7	5784 - Operational Concepts: Using Cases & Scenarios to Understand User's Needs *Mr. Raymond Jorgensen, Rockwell Collins*	Track 7 Tutorial Session 1B7	5784 - Operational Concepts: Using Cases & Scenarios to Understand User's Needs (Cont'd) *Mr. Raymond Jorgensen, Rockwell Collins*
Palm II	Track 8 Tutorial Session 1A8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) *Mr. Abe Meilich, Lockheed Martin*	Track 8 Tutorial Session 1B8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) (Cont'd) *Mr. Abe Meilich, Lockheed Martin*

Buffet Lunch

1:00 pm - 2:45 pm

Track 1 Tutorial Session 1C1	5307 - Requirements Development and Management *Mr. Al Florence, The MITRE Corporation*
Track 2 Tutorial Session 1C2	5326 - Integrating Systems Engineering with Earned Value Management *Mr. Paul Solomon, Performance-Based Earned Value®*
Track 3 Tutorial Session 1C3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
Track 4 Tutorial Session 1C4	5511 - Modeling Sustainment and Risk Mitigation for Net-Enabled Realities *Mr. Philip Boxer, Software Engineering Institute/CMU*
Track 5 Tutorial Session 1C5	5540 - Introduction to Reliability Analysis *Dr. Meng-Lai Yin, Raytheon Company*
Track 6 Tutorial Session 1C6	5544 - How to Define Practical Systems Engineering Metrics *Mr. Timothy Olson, Lean Solutions Institute, Inc.*
Track 7 Tutorial Session 1C7	5582 - Leading Effective System of Systems (SoS) Technical Reviews *Mr. David Walden, Sysnovation, LLC*
Track 8 Tutorial Session 1C8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) *Dr. Abe Meilich, Lockheed Martin*

Break

3:15 pm - 5:00 pm

Track 1 Tutorial Session 1D1	5307 - Requirements Development and Management (Cont'd) *Mr. Al Florence, The MITRE Corporation*
Track 2 Tutorial Session 1D2	5326 - Integrating Systems Engineering with Earned Value Management (Cont'd) *Mr. Paul Solomon, Performance-Based Earned Value®*
Track 3 Tutorial Session 1D3	5404 - How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices (Cont'd) *Mr. Gary Langford, The Naval Postgraduate School*
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Track 8 Tutorial Session 1D8	5577 - Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM) (Cont'd) *Dr. Abe Meilich, Lockheed Martin*

5:00 pm - 6:00 pm Reception in Regatta Pavilion

Tuesday, October 23, 2007

1:30 pm - 3:00 pm

Room	concurrent sessions		
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 2C1	5378 - DoD's Systems Engineering Revitalization Efforts—An Update *Col Richard Hoeferkamp, USAF*	5399 - The Effectiveness of Systems Engineering: on Federal (DoD) System Development Programs *Mr. Al Mink, SRA International*
Bayview B	TRACK 2 *Test & Evaluation in Systems Engineering* Session 2C2	5503 - A Vector Check—Revitalizing DT&E *Mr. Chris DiPetto, OUSD (AT&L)*	5402 - A Test Strategy Done Early Drives Test Planning and Successful Testing *Mr. William Lyders, ASSETT, Inc.*
Bayview C	TRACK 3 *Program Management* Session 2C3	5522 - Systemic Root Cause Analysis of Acquisition Program Issues *Mr. Dave Castellano, OUSD (AT&L)*	Systemic Root Cause Analysis - Emerging Recommendations Industry Panel Discussion *Mr. Dave Castellano, OUSD (AT&L)*
Mission I	TRACK 4 *Integrated Diagnostics* Session 2C4	5797 - Environment, Safety, and Occupational Health (ESOH)—Design Considerations to Support Sustainability and Readiness *Ms. Patricia Huheey, ODUSD (I&E)*	5508 - Integrated Structural Health Monitoring System Using Lamb Waves *Maj Joerg Walter, USAF, Air Force Institute of Technology*
Mission II	TRACK 5 *Modeling & Simulation* Session 2C5	5446 - Implementing the Acquisition M&S Master Plan *Mr. Michael Truelove, SAIC* 5421 - M&S-Related Guidelines for Contracting *Mr. Michael Truelove, SAIC*	5606 - M&S Planning and Employment Best Practices *Mr. James Hollenbach. Simulation Strategies, Inc.*
Mission II	TRACK 6 *Net Centric Operations* Session 2C6	5430 - The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen) *Mr. David Synder, The MITRE Corp.*	5500 - Complex Systems of Systems: The Dual Challenge *Mr. Phillip Boxer, Software Engineering Institute*
Palm I	TRACK 7 *Best Practices & Standardization* Session 2C7	5780 - Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines *Mr. Raymond Jorgensen, Rockwell Collins*	5491 - Systems Engineering Process Improvements at NAVAIR *Mr. Michael Gaydar, Department of Navy, NAVAIR*
Palm II	TRACK 8 *Software* Session 2C8	6163 - DoD Software Engineering and System Assurance *Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering*	6164 - A Reference Curriculum for Software Engineering Graduate Education *Ms. Kristen Baldwin, ODUSD (A&T) Systems and Software Engineering*

Break in the Regatta Pavilion

3:30 pm - 5:00 pm

concurrent sessions			
TRACK 1 *Systems Engineering Effectiveness* Session 2D1	5484 - Tools and Resources to Enable Systems Engineering Improvement *Mr. Michael Kutch, SPAWAR Systems Center Charleston*	5626 - Good Systems Engineering Insures Good Producibility *Dr. Thomas Christian, Aeronautical Systems Center*	5405 - Systems Engineering Realization for the Future *Ms. Karen Bausman, AF Center for Systems Engineering*
TRACK 2 *Test & Evaluation in Systems Engineering* Session 2D2	5489 - Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation *Mr. Joseph Tribble, AVW Technologies*	5774 - Implementing and Measuring Test Program in a Sustainment Environment *Mr. James Miller, USAF*	*Joint Safety Review Process Study* *Ms. Paige Ripini, Booz Allen Hamilton*
TRACK 3 *Program Management* Session 2D3	5779 - Applying Systems Engineering Dring Pre- Acquisition Activities *Lt Col Mark Wilson, USAF*	5435 - Reforming the DoD Acquisition Process—A Systems Engineering Approach *Mr. Stephan Ward, U.S. Air Force*	5365 - PValue of Systems Engineering: Analysis & Results from Previous and Current Studies of Over 100 System Development Projects *Mr. Alan Mink, SRA International*
TRACK 4 *Integrated Diagnostics* Session 2D4	5368 - Real-Time Diagnostics for High Availability Systems *Mr. Edward Beck, Computer Sciences Corporation*	5271 - Leveraging EMS for Condition Based Maintenance *Mr. Bob Heilman, O'Neil & Associates, Inc.*	5287 - Sparing Satellites- Comparitive Strategies of In-orbit & In-factory Storage *Mr. James Mazzei, The Aerospace Corporation*
TRACK 5 *Modeling & Simulation* Session 2D5	5427 - Modeling and Simulation Resource Reuse Business Model *Mr. Dennis Shea, Center for Naval Analyses*	5603 - Modeling and Simulation Support Plan *Mr. David Henry, Lockheed Martin*	6099 - Modeling and Simulation Education for the Acquistion Workforce: Requirements Analysis *Mr. David Olwell, NPS*
TRACK 6 *Net Centric Operations* Session 2D6	5576 - Systems Engineering in the Cognitive and Social Domains of Net Centric Operations *Dr. Abe Meilich, Lockheed Martin*	Global Information Grid (GIG) Technical Foundation (GTF) and GIG Compliance Assessment (GICA) *Mr. Brendan Goode, Booz Allen Hamilton*	Global Information Grid (GIG) Performance Assessment Framework *Mr. Tony Modelfino, Stratogis*
TRACK 7 *Best Practices & Standardization* Session 2D7	5781 - Integrating Engineering Project Management and Product Development Processes *Mr. Raymond Jorgensen, Rockwell Collins*	5831 - Engineering for System Assurance—Legacy, Life Cycle, Leadership *Mr. Paul Croll, Computer Sciences Corporation*	
TRACK 8 *Software* Session 2D8	5315 - Requirements for a Chief Software Engineering in a DoD Acquisition Agency *Mr. Al Florence, The MITRE Corporation*	5481 - Developing an Integrated Process Methodology for Interim Software Releases *Mr. Tim Woods, Southern Methodist University*	

5:00 pm - 6:00 pm Reception in the Regatta Pavilion

Wednesday, October 24, 2007

8:00 am - 9:45 am — concurrent sessions

Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 3A1	5824 - Change Management of UML-Based Systems Engineering Artefacts *Mr. David Price, Eurostep*	5806 - Investigating the Use of SysML on the FBX-T Radar Program *Mr. Chad Schuyler, Raytheon*	5536 - A Day in the Life of a Verification Requirement *Mr. Stephen Scukanec, Northrop Grumman Corporation*
Bayview B	TRACK 2 *Test & Evaluation in Systems Engineering* Session 3A2	5812 - An Update on the DT&E Committee's Recommended Policy Changes to DoD 5000 *Col Richard Stuckey, USAF, OUSD (AT&L)/SSE/DT&E*	5520 - System Test and Evaluation in the DARPA Immune Building Demonstration Program *Mr. Mark Saxon, Battelle*	5553 - Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise *Ms. Shala Malone, Navy Program Executive Office Integrated Warfare*
Bayview C	TRACK 3 *Program Management* Session 3A3	5523 - Systems Engineering Plan Preparation Guide Update *Mr. Chester Bracuto, OSD/AT&L/A&T/SSE/ED*	5525 - Toward a Unified Systems Engineering Plan *Mr. Robert Scheurer, Boeing Integrated Defense Systems*	5587 - Integrating Risk & Knowledge Management *Mr. David Lengyel, NASA*
Mission I	TRACK 4 *Integrated Diagnostics* Session 3A4	5546 - Defining Lean Service and Maintenance Processes *Mr. Timothy Olson, Lean Solutions Institute, Inc.*	5355 - Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard *Mr. Patrick Cumby, VectorCSP, LLC*	
Mission II	TRACK 5 *Modeling & Simulation* Session 3A5	5614 - Live Virtual Constructive (LVC) Architecture Interoperability Assessment *Mr. Warren Bizub, USJFCOM*	5538 - Advancing the FEDEP for Simulation Based Acquisition *Dr. Katherine Morse, SAIC*	
Mission III	TRACK 6 *Net Centric Operations* Session 3A6	5497 - Achieving Agility in Cyberspace *Mr. Phillip Boxer, Software Engineering Institute*	5815 - Distributed Firewalls *Mr. Alejandro Gastelum, Northrop Grumman*	
Palm I	TRACK 7 *Best Practices & Standardization* Session 3A7	5592 - CMMI—Next Steps *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5743 - CMMI Instructional Challenges to Systems Engineers in Small Settings *Dr. Mary Anne Herndon, Transdyne Corporation*	
Palm II	TRACK 8 *Software* Session 3A8	5526 - Defining Software Component Specifications: An Open Approach *Mr. Kenneth Klein, Computer Sciences Corporation*	5676 - System Engineering and Software Exception Handling (SEH) *Mr. Herbert Hecht, SoHaR Incorporated*	

Break in the Regatta Pavilion

10:15 am - 12:00 pm — concurrent sessions

TRACK 1 *Systems Engineering Effectiveness* Session 3B1	5557 - How to Measurably Improve Your Requirements *Mr. Timothy Olson, Lean Solutions Institute, Inc.*	5670 - Review of the Roles of a System Architect *Dr. Dinesh Verma, Stevens Institute of Technology*	5865 - Case Studies: A Common Language Between Engineers and Managers *Capt DeWitt Latimer, USAF*
TRACK 2 *Test & Evaluation in Systems Engineering* Session 3B2	5473 - Joint Mission Environment Test Capability (JMETC) *Mr. Richard Lockhart, Test Resource Management Center*	5585 - Testing Concept of Operations in DoD's Net Centric Environment *Mr. Steve Reeder, South Carolina Research Authority (SCRA)*	
TRACK 3 *Program Management* Session 3B3	5381 - Systems Engineering and Program Management—How Different are They? *Ms. Lori Zipes, Naval Surface Warfare Center PC*	5799 - Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems *Mr. Michael Harper, SPAWAR Systems Center Charleston*	5531 - The Joint Partnership Between Program Management and Systems Engineering *Mr. Samuel Son, The Boeing Company*
TRACK 4 *Logistics, Supportability, and Readiness* Session 3B4	5903 - Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ships *Mr. Michael Mahon, Lockheed Martin*	5530 - Considerations & Propose Approach for Integrating New Hardware & Software into the Legacy Military Aircraft Avionics Systems—A Systems Engineering Lesson-Learned Perspective on the C-17 Program *Mr. Phat Vu, The Boeing Company*	5954 - Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering) Mr. Steven Head, Boeing
TRACK 5 *Modeling & Simulation* Session 3B5	5431 - Acquisition M&S Community Sponsored M&S Project: Standardized Documentation for Verification, Validation, and Accreditation *Mr. Kevin Charlow, Space and Naval Warfare Systems Center Charleston*	5426 - A Methodology for Assessing & Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations *Dr. James Elele, U.S. Navy*	
TRACK 6 *Net Centric Operations* Session 3B6	5386 - Application of Autonomic Agents for Global Information Grid *Mr. David Cox, University of Arizona*	5847 - Architecture-Based Concept Evaluation in Support of JCIDS *Dr. David Jacques, Air Force Institute of Technology*	
TRACK 7 *Best Practices & Standardization* Session 3B7	5808 - FISMA Operational Controls and Their Relationship to Process Maturity *Ms. Rhonda Henning, Harris Corporation*	5485 - Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston *Mr. Michael Kutch, SPAWAR Systems Center Charleston*	CMMI for Services: Re-Introducing the CMMI for Services Constellation *Mr. Craig Hollenbach, Northrop Grumman Corporation*
TRACK 8 *Software* Session 3B8	5764 - A Convergence of Technologies for Better Software NOW! *Ms. Dorothy Acton, Lockheed Martin IS&GS*	5803 - Identifying Acquisition Patterns of Failure Using System Archetypes *Mr. William Novak, Software Engineering Institute*	

12:00 pm Lunch in the Regatta Pavilion

Wednesday, October 24, 2007

1:30 pm - 3:00 pm (concurrent sessions)

Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 3C1	5594 - Handbook on Engineering for System Assurance *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5805 - A Pragmatic Approach for Defining and Utilizing System States and Modes *Mr. Mark Minnucci, Raytheon*
Bayview B	TRACK 2 *Systems Engineering Effectiveness* Session 3C2	5464 - "Do it right, do it early; Do it early, do it right"—Considerations for the Early Stages of Concept, System, and Systems-of-Systems Definition *Mr. Jeff Loren, MTC Technologies, Inc. (SAF/AQRE)*	5380 - Applications of Systems Engineering to Pre-Milestone A Projects *Ms. Lori Zipes, Naval Surface Warfare Center PC*
Bayview C	TRACK 3 *Program Management* Session 3C3	5795 - Lockheed Martin Aeronautics Company Approach to Solving Systemic Development Program Issues *Mr. John Weaver, Lockheed Martin Aeronautics Company*	5450 - Airborne Signals Intelligence Payload (ASIP) Program Integrated Risk Management *Mr. Danial Bolek, USAF*
Mission I	TRACK 4 *Logistics, Supportability, and Readiness* Session 3C4	5843 - Aging Aircraft Sustainment with Non-Standard Engineering *Ms. Kendal Hinton, Georgia Tech Research Institute*	5477 - M109 Howitzer Sustainment *Mr. Peter Henry, BAE Systems Land and Armaments*
Mission II	TRACK 5 *Modeling & Simulation* Session 3C5	5740 - Leveraging the Integrated Engineering Model (IEM) Process as a Lead Systems Integrator *Mr. Anthony Montano, Raytheon Company*	5376 - Experiences in Applying SysML to Develop Interoperable Torpedo Modeling and Simulation Components *Mr. Thomas Haley, Naval Undersea Warfare Center*
Mission III	TRACK 6 *Net Centric Operations* Session 3C6	5848 - System of Systems Implications for Operational Test *Dr. John Colombi, Air Force Institute of Technology*	5519 - Case Study: Net Centric Mission Thread Modeling and Analysis *Dr. Prem Jain, MITRE*
Palm I	TRACK 7 *Best Practices & Standardization* Session 3C7	5760 - How to Paint a Room: The Role of Specs & Standards in SE *Mr. Robert Kuhnen, USAF*	5837 - Continuous Improvement at the Organization, Team, and Individual Levels—Lessons Learned Integrating CMM, TSP, and PSP and Why All Three are Needed *Mr. Girish Seshagiri, Advanced Information Services, Inc.*
Palm II	TRACK 8 *Education & Training* Session 3C8	5350 - Revitalizing Education and Training in Systems Engineering *Dr. Don Gelosh, Department of Defense, OSD(AT&L)/SSE/ED*	5501 - Customer-Driven, Partnership-Based Systems Engineering Education and Training *Mr. Jerrell Stracener, Southern Methodist University*

Break in the Regatta Pavilion

3:30 pm - 5:15 pm (concurrent sessions)

TRACK 1 *Systems Engineering Effectiveness* Session 3D1	5433 - A Practical Application of Structured System Engineering and Failure Mode Effects Analysis to New Technologies *Mr. Paul Deniston, Ford Motor Company*	5505 - Discussion of the U.S. Army RDECOM APS Objective Trade Study *Mr. Frank Salvatore, High Performance Technologies, Inc.*	A Deep Dive into Program Review Findings *Mr. Peter Nolte, OUSD/SSE*
TRACK 2 *Systems Engineering Effectiveness* Session 3D2	5593 - Systems Engineering in a Systems of Systems Environment - Defense Update *Ms. Kristen Baldwin, ODUSD (A&T) SSE/SSA*	5602 - ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project *Mr. G. Richard Thompson, JHU/APL*	5832 - A Brigade Capability Approach to the Evolution of Current Ground Combat Systems *Ms. Roberta Desmond, U.S. Army*
TRACK 3 *Program Management* Session 3D3	5434 - Improvements to the Risk Management Process *Mr. Doug Atkinson, USAF*	5388 - Integrated Risk and Earned Value Management *Mr. Paul Davis, Northrop Grumman*	5800 - Application of Risk Management Practices to NNSA Tritium Readiness Subprogram *Mr. Sham Shete, Washington Savannah River Co.*
TRACK 4 *Logistics, Supportability, and Readiness* Session 3D4	5528 - C-17 Program Applies Systems Engineering to a Large Improvement Project *Mr. Brent Theodore, The Boeing Company*	5854 - Effective Time on Station (ETOS): The Persistent Performance Metric for Aircraft Systems *Mr. Christopher Marchefsky, NAVAIR*	
TRACK 5 *Modeling & Simulation* Session 3D5	5835 - Unifying Systems Engineering Simulations *Mr. Ryan O'Grady, Cybernet Systems Corporation*	5409 - Information Modeling for Systems Integration *Ms. Claudia Rose, BBII*	5575 - Simulation Supported Decision Making *Mr. Gene Allen, MSC Software Corporatiton*
TRACK 6 *Net Centric Operations* Session 3D6	5407 - Quantitative Comparison of Alternative Designs for a JC3M System *Mr. Gregory Miller, Naval Postgraduate School*	5445 - Advanced Net Centric Simulation for Aerospace Command and Control *Ms. Kimberly Kendall, 753d ELSG/NEM, ESC, USAF*	
TRACK 7 *System Safety* Session 3D7	Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program *Ms. Jennifer Malone, EG&G*	Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program *Mr. Ricky Milnarik, Electric Boat Corporation*	The Safety of Unmanned Systems: The Process Used to Develop Safety Precepts for Unmanned Systems *Mr. Mike Demmick, NOSSA*
TRACK 8 *Education & Training* Session 3D8	5873 - Reference Curriculum for a Graduate Program in Systems Engineering *Dr. Rashmi Jain, Stevens Institute of Technology*	5522 - Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula *Dr. David Olwell, Naval Postgraduate School*	5438 - Autopsy of A Good Systems Engineer – An Endangered Species *Mr. Jimmy Thai, SAIC*

Thursday, October 25, 2007

8:00 am - 9:45 am

Room	concurrent sessions			
Bayview A	TRACK 1 *Systems Engineering Effectiveness* Session 4A1	5499 - A Robust Process for Resolving Interface Design Issues in the Complex Concurrent LCS System Engineering Environment *Mr. William Traganza, NAVSEA PMS 485*	5785 - UAI Increasing Flexibility Through Data Driven Interfaces *Mr. Jonathon Miller, USAF —Aeronautical Systems Center*	5785 - Describing Flexibility as an Operational Capability *Mr. Oren Edwards, USAF —Aeronautical Systems Center*
Bayview B	TRACK 2 *Systems Engineering Effectiveness* Session 4A2	5675 - Implementing the Technology Maturity Vector *Mr. Joseph Terlizzese, Systems Engineering Support Office*	5443 - Technology Readiness Assessments; Milestone B Certification Requirement for Technologies to be Demonstrated in a Relevant Environment *Dr. Jay Mandelbaum, Institute for Defense Analyses*	5453 - Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen) *Mr. Jerry Friedman, The MITRE Corporation*
Bayview C	TRACK 3 *Program Management* Session 4A3	5849 - Managing Requirements to Manage Scope in the Case of MUOS *Ms. Christy Howard, Maxim Systems, Inc.*	5867 - Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs *Mr. Francis Sisti, Aerospace Corporation*	5532 - Systems Engineering Approach to Prioritize Projects *Mr. Thomas Condron, USAF (516 AESG/ASC)*
Mission I	TRACK 4 *Logistics, Supportability, and Readiness* Session 4A4	5419 - DoD/OSD Sustainment/ Readiness Initiatives: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE) *Dr. Danny Reed, Institute for Defense Analyses*	5629 - Relating Investment in Reliability Engineering to Reliability Improvement and Reduction of Total Ownership Cost *Dr. James Forbes, LMI*	5493 - Innovation Strategies for Affordable Readiness *Mr. Tom Choinski, Naval Undersea Warfare Center*
Mission II	TRACK 5 *Modeling & Simulation* Session 4A5	5444 - Aircraft Flight Simulator Acceptance Criteria *Mr. Dean Carico, NAWCAD PAX*	5829 - Computer Modeling to Solve Problems with the T-38 Propulsion Modernization Program *Mr. Randall Wimer, USAF - FVB*	
Mission III	TRACK 6 *Net Centric Operations* Session 4A6	5585 - Testing Concept of Operations in DoD's Net Centric Environment *Mr. Steve Reeder, South Carolina Research Authority (SCRA)*	5798 - Agile Governance for SOA-Based Military Systems of Systems *Mr. Robert Beck, Villanova University*	
Palm I	TRACK 7 *System Safety* Session 4A7	5460 - The DoD's Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow's Warfighter and Mission Readiness *Dr. Carole LeBlanc, Office of the Deputy Under Secretary of Defense*	5439 - Safe-Escape Analysis System Safety Engineering Study *Mr. David Hall, SURVICE Engineering Company*	5377 - Risk and System Safety in Aerospace Systems Engineering *Dr. Daniel Schrage, Georgia Tech*
Palm II	TRACK 8 *Education & Training* Session 4A8	5494 - Development of Systems Engineers in the Sensors & SONAR Systems Department *Mr. Lawrence Lazar, Naval Undersea Warfare Center*	5617 - Systems Engineering and the Art of Seeing *Dr. Robert Monson, Lockheed Martin Corporation*	5792 - Understanding Social Networks—A Key Requirement for System Engineers *Mr. Karl Selke, Evidence Based Research, Inc.*

Break in the Regatta Pavilion

10:15 am - 12:00 pm

concurrent sessions		
TRACK 1 *Systems Engineering Effectiveness* Session 4B1	5490 - USAF Type Certification of Commercial Derivative Aircraft *Mr. Thomas Morgan, USAF*	6135 - Global Positioning System Case Study *Mr. Randall Bullard, Air Force Center for Systems Engineering*
TRACK 2 *Systems Engineering Effectiveness* Session 4B2	5759 - Sensor Resource Allocation as a Driver in Ballistic Missile Defense System Concept Development *Mr. Ravi Moorthy, Lockheed Martin MS2*	5369 - Benchmarking Operational Configuration in a Spiral Development Process: Ballistic Missile Defense System *Mr. Hannibal Wright, Barca Strategy and Technology Consulting, LLC*
TRACK 3 *Program Management* Session 4B3	5850 - How to Talk to a Program Manager *Dr. John Mishler, Software Engineering Institute*	U.S. Department of Defense (DoD) Approach to Best Practices: Building Evidence for Practice Selection Based on Real Experiences *Dr. Forrest Shull, Fraunhofer Center Maryland*
TRACK 4 *Logistics, Supportability, and Readiness* Session 4B4	5773 - Implementing a Systems Engineering Risk Program in a Sustainment Environment *Mr. James Miller, USAF*	5826 - Risk Management and Software Life Cycle Selection *Mr. Thomas McDermott, Georgia Tech Research Institute*
TRACK 5 *Modeling & Simulation* Session 4B5	5397 - Efficacy of Modeling & Simulation in Defense Life Cycle Engineering *Mr. Donald Cox, Raytheon Missile Systems*	5355 - Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard *Mr. Patrick Cumby, VectorCSP, LLC*
TRACK 6 *Net Centric Operations* Session 4B6	5820 - Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA *Mr. Tim Greer, Lockheed Martin Corporation*	5320 - Toward an Intelligent Military Enterprise: An Introduction to an Approach to Joint Forces Based on Meta-Systems Theory *Dr. Kent Palmer, UniSA SEEC*
TRACK 7 *System Safety* Session 4B7	Overview of DoD Environment, Safety and Occupational Health Requirements, Terminology, System Safety Methodology and Risk Assessment *Mr. Sherman Forbes, USAF SAF/AQRE*	Overview of Environment, Safety and Occupational Health Activities within Systems Engineering *Mr. Sherman Forbes, USAF SAF/AQRE*

12:00 pm Lunch in the Regatta Pavilion

Thursday, October 25, 2007

concurrent sessions **1:30 pm - 3:00 pm**

Bayview A	TRACK 2 *Systems Engineering Effectiveness* Session 4C2	5814 - Defense System and Large-Scale Systems Based on Terminal Control *Mr. Xiang-Wen Xiong, Zhongheng High-Tech Institute, Inc.*		
Bayview B	TRACK 4 *Logistics, Supportability, and Readiness* Session 4C4	5416 - The Deployment Readiness Service: The Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment *Mr. George Dalton, USAF*		
Bayview C	TRACK 5 *Modeling & Simulation* Session 4C5	5838 - Generic Sensor Model *Dr. Stanley Hack, Lockheed Martin MS-2*	5852 - Event Timeline Analysis in Multi Mission Scenarios with System Simulation Models *Mr. Ravi Moorthy, Lockheed Martin MS2*	5428 - A Prototype Tool for Concept Design Modeling and Optimization of Combat Systems *Mr. Vikram Ganesan, General Dynamics Land Systems*

Conference Adjourns

Track Chairs

Systems Engineering Effectiveness:
- Mr. Al Brown
- Ms. Sharon Vannucci
- Mr. Bob Lyons

Logistics Supportability & Readiness:
- Mr. Chuck Silva
- Mr. Joel Moorvich

Test & Evaluation in Systems Engineering:
- Col Rich Stuckey, USAF
- Mr. Tom Wissink

Program Management:
- Mr. Hal Wilson

Modeling & Simulation:
- Mr. Jim Hollenbach
- Mr. Gary Belie

Net Centric Operations:
- Mr. Jack Zavin
- Dr. Rich Eilers
- Dr. Tom Wickstrom

Best Practices & Standardization:
- Mr. Paul Croll

Software:
- Dr. Tom Christian

Education & Training:
- Mr. George Mooney

Integrated Diognostics:
- Mr. Howard Savage
- Mr. Dennis Hecht

Additional Authors

Track	Abstract	Paper Title	Authors
1A1	5305	Are We Ready for CMMI®? If Not, Let's Fix Ourselves	Mr. Al Florence
1A2	5454	Cost As an Independent Variable and Trade Studies	Mr. Ed Casey
1A3	5404	How to Reduce Schedule Uncertainty by Integrating Sound Management Methods with Systems Engineering Best Practices	Mr. Gary Langford
1A4	5498	System Verification Organization Tutorial	Mr. Jeffrey Grady
1A6	5542	Best-In-Class Early Defect Detection and Defect Prevention	Mr. Timothy Olson
1A7	5784	Operational Concepts: Using Cases & Scenarios to Understand User's Needs	Mr. Raymond Jorgensen
1A8	5577	Introduction to SysML & Object Oriented Systems Engineering Methodology (OOSEM)	Mr. Abe Meilich
1C1	5307	Requirements Development and Management	Mr. Al Florence
1C2	5326	Integrating Systems Engineering with Earned Value Management	Mr. Paul Solomon
1C4	5511	Modeling Sustainment and Risk Mitigation for Net-Enabled Realities	Mr. Philip Boxer Ms. Lisa Brownsword Mr. Bill Anderson Mr. Jim Smith
1C5	5540	Introduction to Reliability Analysis	Dr. Meng-Lai Yin
1C6	5544	How to Define Practical Systems Engineering Metrics	Mr. Timothy Olson
1C7	5582	Leading Effective System of Systems (SoS) Technical Reviews	Mr. David Walden
2C1	5378	DoD's Systems Engineering Revitalization Efforts—An Update	Mr. Robert Skalamera Col Richard Hoeferkamp
2C1	5399	The Effectiveness of Systems Engineering: On Federal (DoD) System Development Programs	Mr. Al Mink Mr. Dennis Goldenson Mr. Geoff Draper Mr. Al Brown Mr. Ken Ptack
2C2	5402	A Test Strategy Done Early Drives Test Planning and Successful Testing	Mr. William Lyders
2C2	5503	A Vector Check - Revitalizing DT&E	Mr. Chris DiPetto
2C3	5531	The Joint Partnership Between Program Management and Systems Engineering	Mr. Samuel Son
2C4	5508	Integrated Structural Health Monitoring System Using Lamb Waves	Maj Joerg Walter, USAF Dr. Som Soni
2C4	5797	Environment, Safety, and Occupational Health (ESOH) - Design Considerations to Support Sustainability and Readiness	Ms. Patricia Huheey Ms. Karen Gill
2C5	5421	M&S-Related Guidelines for Contracting	Mr. Michael Truelove
2C5	5446	Implementing the Acquisition M&S Master Plan	Mr. Michael Truelove Mr. Jim Hollenbach
2C5	5606	M&S Planning and Employment Best Practices	Mr. Jim Hollenbach
2C6	5430	The Use of Enterprise Architecture to Support the Development of the Next Generation Air Transportation System (NextGen)	Mr. Jerry Friedman Mr. David Snyder
2C6	5500	Complex Systems of Systems: The Dual Challenge	Mr. Philip Boxer Ms. Lisa Brownsword Mr. Ed Morris
2C7	5491	Systems Engineering Process Improvements at NAVAIR	Mr. Michael Gaydar
2C7	5780	Simplifying & Scaling Engineering Processes: Unifying Business Units and Engineering Disciplines	Mr. Raymond Jorgensen
2D1	5405	Systems Engineering Realization for the Future	Ms. Karen Bausman
2D1	5484	Tools and Resources to Enable Systems Engineering Improvement	Mr. Michael Kutch, Jr. Mr. Michael Knox

2D1	5626	Good Systems Engineering Insures Good Producibility	Dr. Thomas Christian, Jr. Mr. Rich Stepler Mr. Hamid Akhbar
2D2	5489	Applying Design of Experiments Methodology to Sortie Generation Rate Evaluation	Mr. Joseph Tribble Mr. Matthew Rodakis
2D2	5774	Implementing and Measuring Test Program in a Sustainment Environment	Mr. James Miller
2D3	5365	PValue of Systems Engineering: Analysis & Results from Previous and Current Studies of Over 100 System Development Projects	Mr. Allan Mink, II
2D3	5435	Reforming the DoD Acquisition Process - A Systems Engineering Approach	Mr. Stephen Ward Mr. Christopher Perkins
2D3	5779	Applying Systems Engineering During Pre-Acquisition Activities	Lt Col Mark Wilson, USAF Mr. Jeff Loren
2D4	5271	Leveraging EMS for Condition Based Maintenance	Mr. Thomas Hawley
2D4	5287	Sparing Satellites--Comparitive Strategies of In-Orbit & In-Factory Storage	Mr. James Mazzei Mr James Ayers Ms. Camille Keeley Mr. Jon Westergaard
2D4	5368	Real-Time Diagnostics for High Availability Systems	Mr. Edward Beck
2D5	5427	Modeling and Simulation Resource Reuse Business Model	Mr. Dennis Shea Dr. John Hampson
2D5	5603	Modeling and Simulation Support Plan	Mr. David Henry
2D5	6099	Modeling and Simulation Education for the Acquisition Workforce: Requirements Analysis	Mr. David Olwell Ms. Jean Johnson
2D6	5576	Systems Engineering in the Cognitive and Social Domains of Net Centric Operations	Dr. Abe Meilich
2D6		Global Information Grid (GIG), Technical Foundation (GTF) and GIG Compliance Assessment (GICA)	Mr. Brendan Goode
2D6		Global Information Grid (GIG) Performance Assessment Framework	Mr. Tony Modelfino
2D7	5781	Integrating Engineering Project Management and Product Development Processes	Mr. Raymond Jorgensen
2D7	5831	Engineering for System Assurance – Legacy, Life Cycle, Leadership	Mr. Paul Croll
2D8	5315	Requirements for a Chief Software Engineering in a DoD Acquisition Agency	Mr. Al Florence
2D8	5481	Developing An Integrated Process Methodology For Interim Software Releases	Mr. Tim Woods Mr. Jerrell Stracener
3A1	5536	A Day in the Life of a Verification Requirement	Mr. Stephen Scukanec Mr. James van Gaasbeek
3A1	5806	Investigating the Use of SysML on the FBX-T Radar Program	Mr. Chad Schuyler Mr. Mark Minnucci Ms. Caroline Elias
3A1	5824	Change Management of UML-Based Systems Engineering Artefacts	Mr. David Price
3A2	5520	System Test and Evaluation in the DARPA Immune Building Demonstration Program	Mr. Mark Saxon Mr. James Risser
3A2	5553	Modeling and Simulation in the Navy Warfare Systems Test & Evaluation Enterprise	Ms. Shala Malone Mr. Richard Reading
3A3	5523	Systems Engineering Plan Preparation Guide Update	Mr. Chester Bracuto
3A3	5525	Toward a Unified Systems Engineering Plan	Mr. Robert Scheurer
3A3	5587	Integrating Risk & Knowledge Management	Mr. David Lengyel
3A4	5546	Defining Lean Service and Maintenance Processes	Mr. Timothy Olson
3A5	5538	Advancing the FEDEP for Simulation Based Acquisition	Dr. Katherine Morse Mr. Paul Lowe
3A5	5614	Live Virtual Constructive (LVC) Architecture Interoperability Assessment	Mr. Warren Bizub Mr. Ken Goad

3A6	5497	Achieving Agility in Cyberspace	Mr. Philip Boxer Mr. Edwin Morris
3A6	5815	Distributed Firewalls	Mr. Alejandro Gastelum
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3A7	5743	CMMI Instructional Challenges to Systems Engineers in Small Settings	Dr. Mary Anne Herndon
3A8	5526	Defining Software Component Specifications: An Open Approach	Mr. Kenneth Klein
3A8	5676	System Engineering and Software Exception Handling (SEH)	Mr. Herbert Hecht
3B1	5557	How to Measurably Improve Your Requirements	Mr. Timothy Olson
3B1	5670	Review of the Roles of a System Architect	Mr. Tomasz Lomecki Dr. Dinesh Verma Mr. Eirik Hole
3B1	5865	Case Studies: A Common Language Between Engineers and Managers	Capt DeWitt Latimer IV, USAF
3B2	5473	Joint Mission Environment Test Capability (JMETC)	Mr. Richard Lockhart
3B2	5585	Testing Concept of Operations in DoD's Net Centric Environment	Mr. John Eleazer Mr. Charles Reeder
3B3	5381	Systems Engineering and Program Management – How Different are They?	Ms. Lori Zipes
3B3	5799	Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems	Mr. Michael Harper Mr. Philip Butler Dr. Jerrell Stracener
3B4	5530	Considerations & Propose Approach for Integrating New Hardware and Software into the Legacy Military Aircraft Avionics Systems – a Systems Engineering Lesson-Learned Perspective on the C-17 Program	Mr. Phat Vu
3B4	5903	Asset-Based PBL for Navy Warships – A Case Study for LCS Class Ship	Mr. Michael Mahon
3B4	5954	Integrated Diagnostics Closed Loop Data System (At the Point of Use) (Support Systems Knowledge Engineering Enhances Traditional Support Equipment Systems Engineering)	Mr. Steven Head Mr. John Bauer
3B5	5426	A Methodology for Assessing and Prioritizing the Risks Associated with the Level of Verification, Validation and Accreditation (VV&A) of Models and Simulations	Dr. James Elele
3B5	5431	Standardized Documentation for Verification, Validation, and Accreditation - A Status Report to the Systems Engineering Community	Mr. Kevin Charlow Mr. Curtis Blais Mr. David Broyles Ms. Marcy Stutzman
3B6	5386	Application of Autonomic Agents for Global Information Grid	Mr. David Cox Mr. Youssif Al-Nashif Dr. Salim Hariri
3B6	5847	Architecture-Based Concept Evaluation in Support of JCIDS	Dr. David Jacques Dr. John Colombi
3B7	5485	Executing a Successful CMMI Maturity Level 3 SCAMPI For SPAWAR Systems Center Charleston	Mr. Michael Kutch Ms. Sandra Guidry
3B7	5808	FISMA Operational Controls and Their Relationship to Process Maturity	Mr. Ronda Henning
3B8	5764	A Convergence of Technologies for Better Software NOW!	Mr. Dorothy Acton
3B8	5803	Identifying Acquisition Patterns of Failure Using System Archetypes	Mr. William Novak Dr. Linda Levine
3B8	5883	Acoustic Rapid COTS Insertion (ARCI) Advanced Processor Build (APB) Systems	Mr. Gary Tissandier
3C1	5594	Handbook on Engineering for System Assurance	Ms. Kristen Baldwin Ms. Christine Hines
3C1	5805	A Pragmatic Approach for Defining and Utilizing System States and Modes	Mr. Mark Minnucci Mr. Chad Schuyler Ms. Caroline Elias

3C2	5380	Applications of Systems Engineering to Pre-Milestone A Projects	Ms. Lori Zipes
3C2	5464	"Do it right, do it early; Do it early, Do it right" -- Considerations for the Early Stages of Concept, System, and Systems-of-Systems Definition	Mr. Jeff Loren Lt Col Mark Wilson
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3C6	5848	System of Systems Implications for Operational Test	Dr. John Colombi Dr. David Jacques
3C7	5760	How to Paint a Room: The Role of Specs & Standards in SE	Mr. Robert Kuhnen
3C7	5837	Continuous Improvement at the Organization, Team, and Individual Levels - Lessons Learned Integrating CMM, TSP, and PSP and Why All Three are Needed	Mr. Girish Seshagiri
3C8	5350	Revitalizing Education and Training in Systems Engineering	Dr. Don Gelosh
3C8	5501	Customer-Driven, Partnership-Based Systems Engineering Education and Training	Dr. Jerrell Stracener Dr. Steven Szygenda Mr. James Rodenkirch
3D1	5433	A Practical Application of Structured System Engineering and Failure Mode Effects Analysis to New Technologies	Mr. Paul Deniston
3D1	5505	Discussion of the U.S. Army RDECOM APS Objective Trade Study	Mr. Frank Salvatore
3D2	5593	Systems Engineering in a Systems of Systems Environment - Defense Update	Ms. Kristen Baldwin Dr. Judith Dahmann Mr. Ralph Lowry
3D2	5602	ASW System-of-Systems Engineering Analysis Applied in an LCS ASW Integration Pilot Project	Mr. G. Richard Thompson
3D2	5832	A Brigade Capability Approach to the Evolution of Current Ground Combat Systems	Ms. Roberta Desmond Mr. Kenneth Mick Mr. Rick Burtnett
3D3	5388	Integrated Risk and Earned Value Management	Mr. Paul Davis
3D3	5434	Improvements to the Risk Management Process	Mr. Doug Atkinson Ms. Amy Mercado Vince
3D3	5800	Application of Risk Management Practices to NNSA Tritium Readiness Subprogram	Mr. Sham Shete Mr. Srini Venkatesh
3D4	5528	C-17 Program Applies Systems Engineering to a Large Improvement Project	Mr. Brent Theodore
3D4	5854	Effective Time on Station (ETOS): The Persistent Performance Metric for Aircraft Systems	Mr. Christopher Marchefsky
3D5	5409	Information Modeling for Systems Integration	Ms. Claudia Rose Mr. Al Brenner Ms. Kim Idol
3D5	5575	Simulation Supported Decision Making	Mr. Gene Allen

3D5	5835	Unifying Systems Engineering Simulations	Mr. Kevin Tang Mr. Glenn Beach Mr. Rakesh Patel Mr. Jason Ueda
3D6	5407	Quantitative Comparison of Alternative Designs for JC3M System	Mr. Gregory Miller Mr. Ian Finn
3D6	5445	Advanced Net Centric Simulation for Aerospace Command and Control	Ms. Kimberly Kendall
3D7		Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program	Mr. Ricky Milnarik Mr. Bryan Stanley Mr. Thomas Cook Mr. Norman Gauthier
3D7		Addressing Environment, Safety and Occupational Health Issues for the Mine Resistant Ambush Protected (MRAP) Vehicle Program	Ms. Jennifer Malone
3D7			Mr. Mike Demmick
3D8	5438	Autopsy of A Good Systems Engineer – An Endangered Species	Mr. Jimmy Thai
3D8	5522	Systemic Root Cause Analysis of Acquisition Program Issues	Mr. Dave Castellano Ms. Laura Dwinnell
3D8	5873	Reference Curriculum for a Graduate Program in Systems Engineering	Dr. Rashmi Jain Dr. Dinesh Verma Mrs. Anithashree Chandrasekara
4A1	5499	A Robust Process for Resolving Interface Design Issues in the Complex Concurrent LCS System Engineering Environment	Mr. William Traganza Mr. Joseph Conway Mr. Joseph Darwood
4A1	5785	UAI Part 1: Increasing Flexibility Through Data Driven Interfaces; Part 2: Describing Flexibility as an Operational Capability	Mr. Jonathan Miller Mr. Oren Edwards
4A2	5443	Technology Readiness Assessments; Milestone B Certification Requirement for Technologies To Be Demonstrated in a Relevant Environment	Dr. Jay Mandelbaum
4A2	5453	Meeting Enterprise System Engineering Challenges for the U.S. Next Generation Air Transportation System (NextGen)	Ms. Catherine Bolczak Mr. Robert Humbertson Mr. John Mack Mr. Gerald Friedman
4A2	5675	Implementing the Technology Maturity Vector	Mr. Joseph Terlizzese, Jr.
4A3	5532	Systems Engineering Approach to Prioritize Projects	Mr. Thomas Condron Maj Christopher Lardner
4A3	5849	Managing Requirements to Manage Scope in the Case of MUOS	Ms. Christy Howard Ms. Debra Shannon CDR Ralph (Trip) Braund
4A3	5867	Organizational Leadership and Management Dynamics for Technical Execution in Acquisition Programs	Mr. Francis Sisti Captain DeWitt Latimer, IV
4A4	5419	DoD/OSD Sustainment/Readiness Initiatives: Reduction of Total Ownership Costs (R-TOC) and Value Engineering (VE)	Dr. Danny Reed Mr. David Erickson
4A4	5493	Innovation Strategies for Affordable Readiness	Mr. Tom Choinski
4A4	5629	Relating Investment In Reliability Engineering To Reliability Improvement And Reduction Of Total Ownership Cost	Dr. James Forbes Mr. E. Andrew Long
4A5	5444	Aircraft Flight Simulator Acceptance Criteria	Mr. Dean Carico
4A5	5829	Computer Modeling to Solve Problems with the T-38 Propulsion Modernization Program	Mr. Randall Wimer Mr. Andrew Hall
4A6	5798	Agile Governance for SOA-Based Military Systems of Systems	Dr. Robert Beck Ms. Jessica Byrnes Ms. Elliot Sloane Ms. Sue Metzger
4A7	5377	Risk and System Safety in Aerospace Systems Engineering	Dr. Daniel Schrage

4A7	5439	Safe-Escape Analysis System Safety Engineering Study	Ms. David Hall Mr. Kenneth Chirkis
4A7	5460	The DoD's Proactive Approach to Emerging Contaminants: Managing Risks Today for Tomorrow's Warfighter and Mission Readiness	Dr. Carole LeBlanc
4A8	5494	Development of Systems Engineers in the Sensors & SONAR Systems Department	Mr. Lawrence Lazar
4A8	5617	Systems Engineering and the Art of Seeing	Dr. Robert Monson
4A8	5792	Understanding Social Networks- A Key Requirement for System Engineers	Mr. Karl Selke
4B1	5490	USAF Type Certification of Commercial Derivative Aircraft	Mr. Thomas Morgan Mr. Joel Ligon
4B1	6135	Global Positioning System Case Study	Mr. Randall Bullard
4B2	5369	Benchmarking Operational Configuration in a Spiral Development Process: Ballistic Missile Defense System	Mr. Hannibal Wright
4B2	5759	Sensor Resource Allocation as a Driver in Ballistic Missile Defense System Concept Development	Mr. Ravi Moorthy Mr. Jay Davidson Mr. Mark Russel
4B3	5850	How to Talk to a Program Manager	Ms. Anita Carleton Dr. William Nichols Dr. John Mishler
4B4	5773	Implementing a Systems Engineering Risk Program in a Sustainment Environment	Mr. James Miller
4B4	5826	Risk Management and Software Life Cycle Selection	Mr. Thomas McDermott
4B5	5355	Modeling Integrated Logistics Systems to Support Transformation in the U.S. Coast Guard	Mr. Patrick Cumby
4B5	5397	Efficacy of Modeling & Simulation in Defense Life Cycle Engineering	Mr. Donald Cox Dr. Salim Hariri
4B6	5320	Toward an Intelligent Military Enterprise: An Introduction to an Approach to Joint Forces Based on Meta-Systems Theory	Dr. Kent Palmer
4B6	5820	Reducing Acquisition Costs Through Incremental Upgrades by Migrating to SOA	Mr. Tim Greer
4B7		Overview of DoD Environment, Safety and Occupational Health Requirements, Terminology, System Safety Methodology and Risk Assessment	Mr. Sherman Forbes
4B7		Overview of Environment, Safety and Occupational Health Activities Within Systems Engineering	Mr. Sherman Forbes
4C2	5814	Defense System and Large-Scale Systems Based on Terminal Control	Mr. Xiang-Wen Xiong
4C4	5416	The Deployment Readiness Service: A Case Study of the Challenges of Implementing a Service Oriented Architecture in a Legacy System Environment	Mr. George Dalton, II Dr. Robert Mills
4C5	5428	A Prototype Tool for Concept Design Modeling and Optimization of Combat Systems	Mr. Vikram Ganesan Mr. Philip Morgan
4C5	5838	Generic Sensor Model	Dr. Stanley Hack Dr. Josef Keith
4C5	5852	Event Time Line Analysis in Multi Mission Scenarios with System Simulation Models	Mr. Ravi Moorthy Mr. Paolo Trinchieri Mr. Todd Brown

Displayers

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Vitech Corporation

Notes

CMMI for Services:
Re-introducing the CMMI for Services Constellation

NDIA Systems Engineering Conference
October 22-25, 2007

Craig R. Hollenbach
Northrop Grumman Corporation

Brandon Buteau
Northrop Grumman Corporation

Drew Allison
Systems and Software Consortium Inc.

Frank Niessink
DNV-CIBIT

Agenda

- CMMI-SVC News
- Overview of the draft CMMI for Services (CMMI-SVC)
  - What is the CMMI?
  - Why is the CMMI-SVC needed?
  - How are services different?
  - What is the basis for the CMMI-SVC model?
  - What is the scope and content of the CMMI-SVC?
- Feedback to date
  - What was the result of the expert review?
  - What was the experience of the pilot projects?
- Next Steps
  - What is the schedule?
  - How can I participate?

CMMI Steering Group to Address CMMI for Services

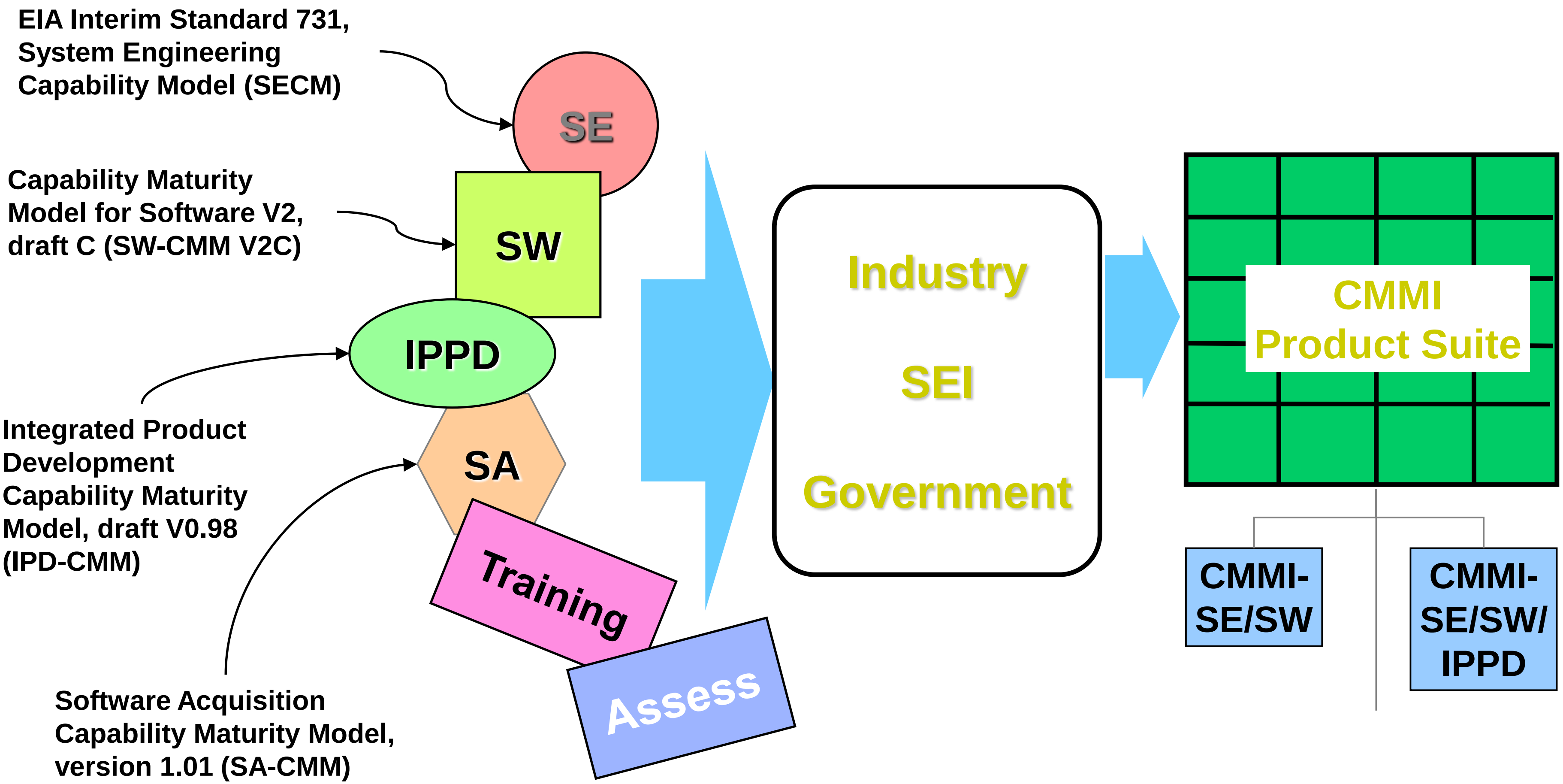
- There was a serious concern that concurrent development of the CMMI-ACQ and CMMI-SVC models would stress the SEI resources needed to deliver the CMMI-ACQ model on time. Now that CMMI-ACQ is almost released, the SEI resources are available to go forward with the CMMI-SVC.
- The CMMI-SVC team will address past Steering Group concerns at their Nov meeting and present a plan to complete development.

What is a Capability Maturity Model (CMM)?

- A conceptual framework for structuring, understanding, and evaluating the capability and maturity of an organization's processes
  - more than a laundry list of best practices
  - more than a collection of benchmarks and metrics
- A tool that enables meaningful, in-depth organizational assessment
  - internally
  - externally
- A map that guides practical process improvement and institutionalizes it
  - How to you get from *here* to *there* and *stay there*?

What is the CMMI?

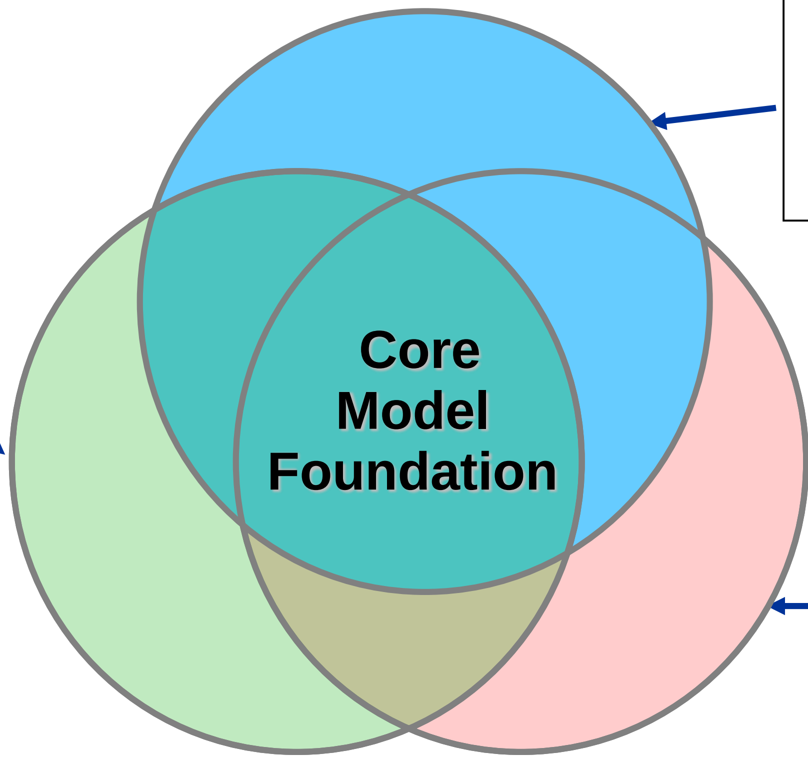
- The CMM Integration℠ (CMMI) of multiple CMMs into a single unified framework



Three complementary constellations

CMMI-DEV
provides guidance for measuring, monitoring, and managing development processes

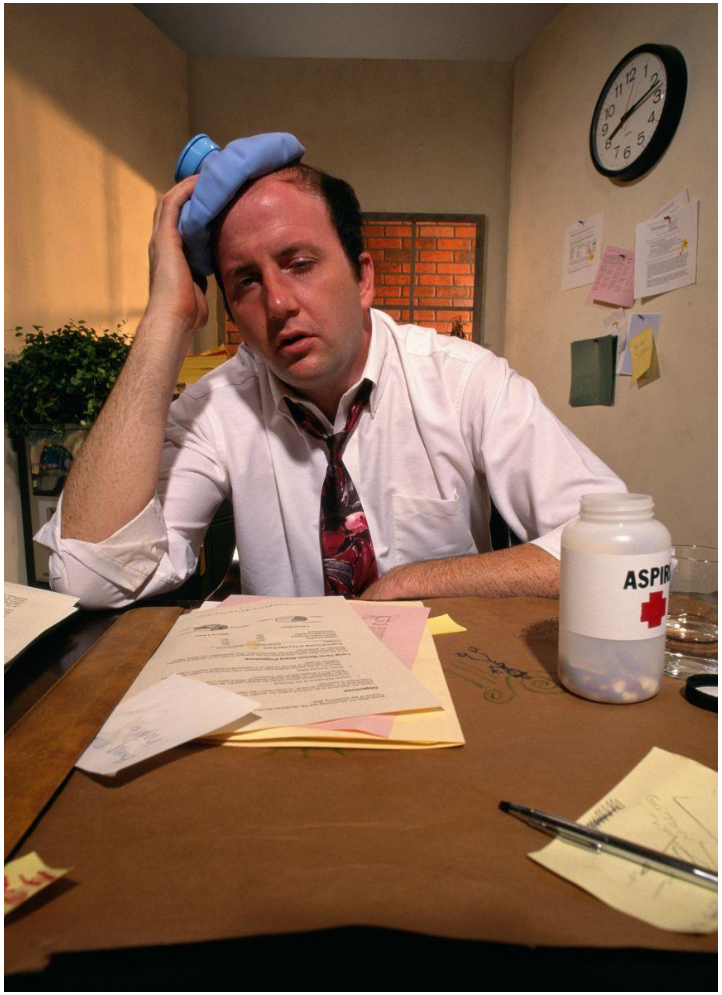
CMMI-SVC
provides guidance for those providing services within organizations and to external customers



CMMI-ACQ
provides guidance to enable informed and decisive acquisition leadership

Courtesy of the SEI

Why is CMMI for Services (CMMI-SVC) needed?



- Customer discontent
- Service society
- Legislation
- Government and industry trends

How are services different?

- Services form a distinctive category of products
  - A service is an intangible, non-storable product
  - What makes a service intangible or non-storable?
    - Customer desires a situation or state (e.g., to have high network availability) rather than a tangible artifact
    - Provider delivers value without allowing the customer independent, unrestricted means to generating/employing that value (e.g., leasing vehicles)
    - Product delivery requires continuing application of labor (e.g., operation of a facility)
- Services imply customer/provider relationships governed by service agreements
  - Service and non-service products may be delivered as part of a single agreement (e.g., training that includes hardcopy materials)
- Services are often delivered via the operation of a service system

Service system

- A necessary concept for understanding the effective delivery of services
- An integrated and interdependent combination of processes, resources, and people that satisfies service requirements.
- Portions are not delivered to the customer or end-user as part of service delivery
- Portions may remain owned by the customer or end-user before service delivery begins and after service delivery ends.
- Encompasses everything required for service delivery, including work products, processes, infrastructure, consumables, and customer resources.

What is the scope of CMMI-SVC?

- Covers practices required to manage, establish, and deliver services, in four process area categories
  - Project (service) management
  - Process management
  - Service support
  - Service establishment and delivery
- Intended to match the scope of the definition of services
- Broad applicability to a range of service domains
  - Information technology, engineering, defense, transportation, finance, health care
- Staff augmentation services need careful consideration
  - How do you evaluate process improvement for processes over which you have no control?

CMMI-SVC Process Areas

- **Process Management**
- Organizational Innovation and Deployment (OID)
- Organizational Process Definition (OPD)
- Organizational Process Focus (OPF)
- Organizational Process Performance (OPP)
- *Organizational Service Management* (OSM)
- Organizational Training (OT)

- **Service Support**
- Causal Analysis and Resolution (CAR)
- Configuration Management (CM)
- Decision Analysis and Resolution (DAR)
- Measurement and Analysis (MA)
- *Problem Management* (PRM)
- Process and Product Quality Assurance (PPQA)

Service Establishment and Delivery

- *Incident and Request Management* (IRM)
- *Service Delivery* (SD)
- *Service System Development* (SSD)
- *Service Transition* (ST)

Project Management

- *Capacity and Availability Management* (CAM)
- Integrated Project Management (IPM)
- Project Monitoring and Control (PMC)
- Project Planning (PP)
- Requirements Management (REQM)
- Risk Management (RSKM)
- Quantitative Project Management (QPM)
- *Service Continuity* (SCON)
- Supplier Agreement Management (SAM)

Services-specific PAs

Process Area	Maturity Level	Specific Goals/ Practices
Capability and Availability Management (CAM)	3	2 / 6
Incident and Request Management (IRM)	2	2 / 6
*Organizational Service Management (OSM)**	3	2 / 7
Problem Management (PRM)	3	2 / 7
*Service Continuity (SCON)**	3	3 / 10
Service Delivery (SD)	3	2 / 7
*Service System Development (SSD) **	3	3 / 12
Service Transition (ST)	3	3 / 12

* optional process areas (independent named additions)

CMMI-SVC Level 2 PAs

- Incident and Request Management
  - To ensure the timely resolution of requests for service and incidents that occur during service delivery
- Requirements Management
  - Extended from the Core Model Foundation with an additional goal
  - To include the establishment and maintenance of written agreements between service providers and customers on service requirements and service levels.
- Six other level 2 PAs from the CMF

CMMI-SVC Level 3 PAs

- Capacity and Availability Management
  - To plan and monitor the effective provision of resources to support service requirements
- Problem Management
  - To prevent incidents from recurring by identifying and addressing underlying causes of incidents
- Service Delivery
  - To deliver services in accordance with service agreements
- Service Transition
  - To deploy new or significantly changed service systems while managing their effect on ongoing service delivery

Optional PAs for CMMI-SVC Level 3

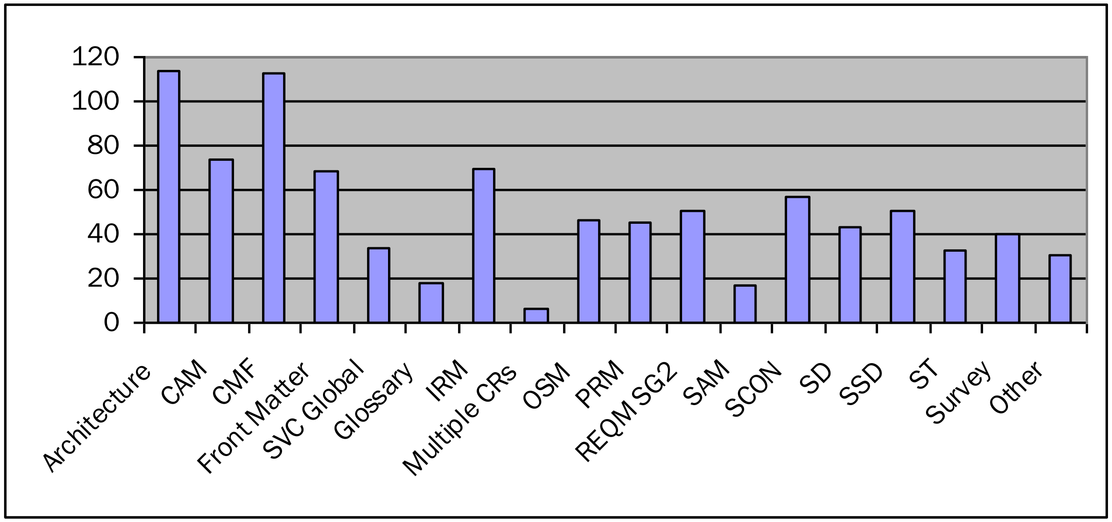
- Organizational Service Management
  - To establish and maintain standard services that ensure the satisfaction of the organization's customer base
- Service Continuity Management
  - To establish and maintain contingency plans for continuity of agreed services during and following any significant disruption of normal operations
- Service System Development
  - To analyze, design, develop, integrate, and test service systems to satisfy existing or anticipated service agreements

What was the result of the expert review?

- An expert review was held Jan 23 - Mar 23, 2007
  - 500+ reviewers, representing:
    - 50 companies,
    - 14 DoD organizations,
    - 4 academic institutions, and
    - 7 professional, governmental, or research centers
    - Reviewers included SEI transition partners
- Response showed strong interest in CMMI-SVC
  - 900+ change requests compares favorably to those received for CMMI-DEV
  - 50 survey responses to architectural questions

What was the result of the expert review? (more)

- Reviews commented mostly on CMM-SVC architecture & Common Model Foundation material
- CRs were distributed equally among categories related to SVC PAs
- CMMI-SVC team has analyzed all architectural CRs; most have a proposed resolution
- CRs showed excellent depth of insight and rich informative content



Sample Survey Responses

- The service practices that are covered in CMMI-SVC will enable service organizations to provide more effective support to their customers.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
78.9%	8.8%	12.3%

- The material in CMMI-SVC yields a useful adaptation of CMMI best practices as they relate to service deployment.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
66.7%	14.0%	15.8%

- CMMI-SVC does not impose constraints (derived from the needs of a specific service or market segment) that would limit or prevent other organizations from adapting the model to their own specific needs.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
55.6%	29.6%	27.8%

- The CMMI-SVC is easy to understand and apply to a service organization.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
42.8%	27.8%	29.6%

What was the experience of the pilot projects?

- Planned pilots were postponed
- CMMI-SVC participating companies piloted the model internally
- Characteristics of the piloted organizations:
  - Most had implemented CMMI-DEV
  - Some had separate ITIL and ISO 20000 initiatives
  - Most are moving towards integration under CMMI umbrella
- The pilots represented the following service domains:

Company	**Service Domains**
SSCI	IT Application Operations & Support
DNV-CIBIT	Banking
Northrop Grumman	Logistics, HR, IT, Applications O&M

What did the pilots see as benefits?

- Improved quality of services
- Encouraged a disciplined culture for service management
  - Better management visibility into services
  - Fewer surprises
  - Fosters process improvement
- Less Interpretation issues (& appraisal expense) than with CMMI-DEV
- Applying a CMMI process to the services brought credibility and buy-in from stakeholders
- Increased sharing between development and services communities
  - Common processes
  - Standard terminology
  - Integrated process improvement standards and models
- Encouraged end-to-end lifecycle process approach helping to identify service requirements, ease deployment issues, reduce stove-piped groups, and improve efficiencies of support-related groups (IT Applications)

What did the pilots see as challenges?

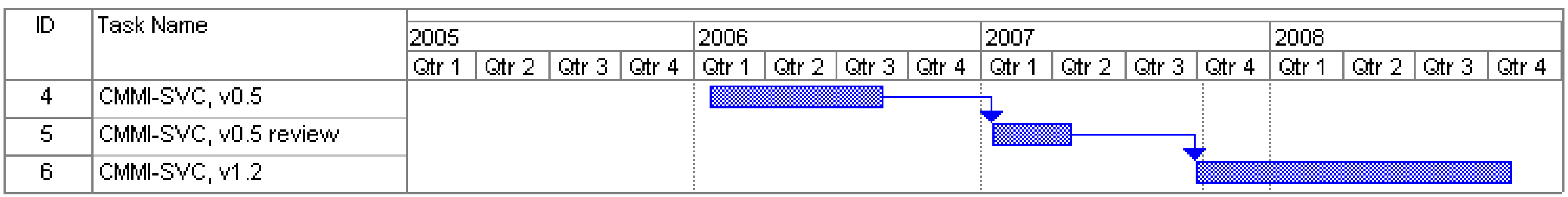
- Obtaining funding in environments that are primarily LOE-based
- Differences in terminology between development and services
  - Terms like “Project” (funding period), “Product” (service), “Work Product”, “Product Component”, “Requirement”
  - Interpreting CMMI’s “project” term for services
- No standard life-cycle definition for services
- Instilling project management culture in services
  - Weak in using requirements for planning and negotiating resources and activities
- Ownership of service system components not as clear
- Release management and deployment to non-standardized, constantly changing environments
- Finding CMMI-knowledgeable individuals who also know services
- Integrating process groups and assets
- Services where customer and provider share resources and processes
- Staff augmentation

Issues to Address

- What is the business case for the CMMI-SVC?
- What distinguishes CMMI-SVC from CMMI-DEV (v1.2) and other models?
- What are the characteristics of service providers and how are they represented in the CMMI-SVC?
- Can the broad spectrum of services be governed by a single model?
- How will the Services Sector be engaged?
- What are the impacts to small businesses?
- How will CMMI-SVC be used with other CMMI products?

What is the schedule?

- CMMI-SVC team will meet to review additional requirements and re-plan remaining work (early Nov)
- Detailed schedule is pending
- A preliminary estimate for release of CMMI-SVC, v1.2 is 4th quarter 2008



How can I participate?

- Get more information about CMMI-SVC
  - CMMI web page - http://www.sei.cmu.edu/cmmi/
  - CMMI for Services Public Workspace (http://bscw.sei.cmu.edu/bscw/bscw.cgi/0/424939) contains:
    - Draft CMMI-SVC model, v0.5
    - Information on joining CMMI-SVC information email list
- Review draft CMMI-SVC release
- If already experienced in CMMI, consider piloting the model
- Other opportunities may exist as a result of the CMMI-SVC re-planning effort; watch CMMI-SVC public workspace for updates

Backup

References

- CMMI - http://www.sei.cmu.edu/cmmi/cmmi.html
- ITIL - http://www.ogc.gov.uk/index.asp?id=2261
- itSMF - http://www.itsmf.com/
- BS 15000 - http://www.bs15000.org.uk/
- COBIT - http://www.isaca.org/
- ITSCMM - http://www.itservicecmm.org/
- Interpreting Capability Maturity Model Integration (CMMI) for Operational Organizations, Brian P. Gallagher, Technical Note, CMU/SEI-2002-TN-006, April 2002
- Interpreting Capability Maturity Model Integration (CMMI) for Service Organizations – a Systems Engineering and Integration Services Example, Mary Anne Herndon, SAIC, et al, Technical Note, CMU/SEI-2003-TN-005, November 2003
- Services CMMI Public Website - http://bscw.sei.cmu.edu/bscw/bscw.cgi/0/424939

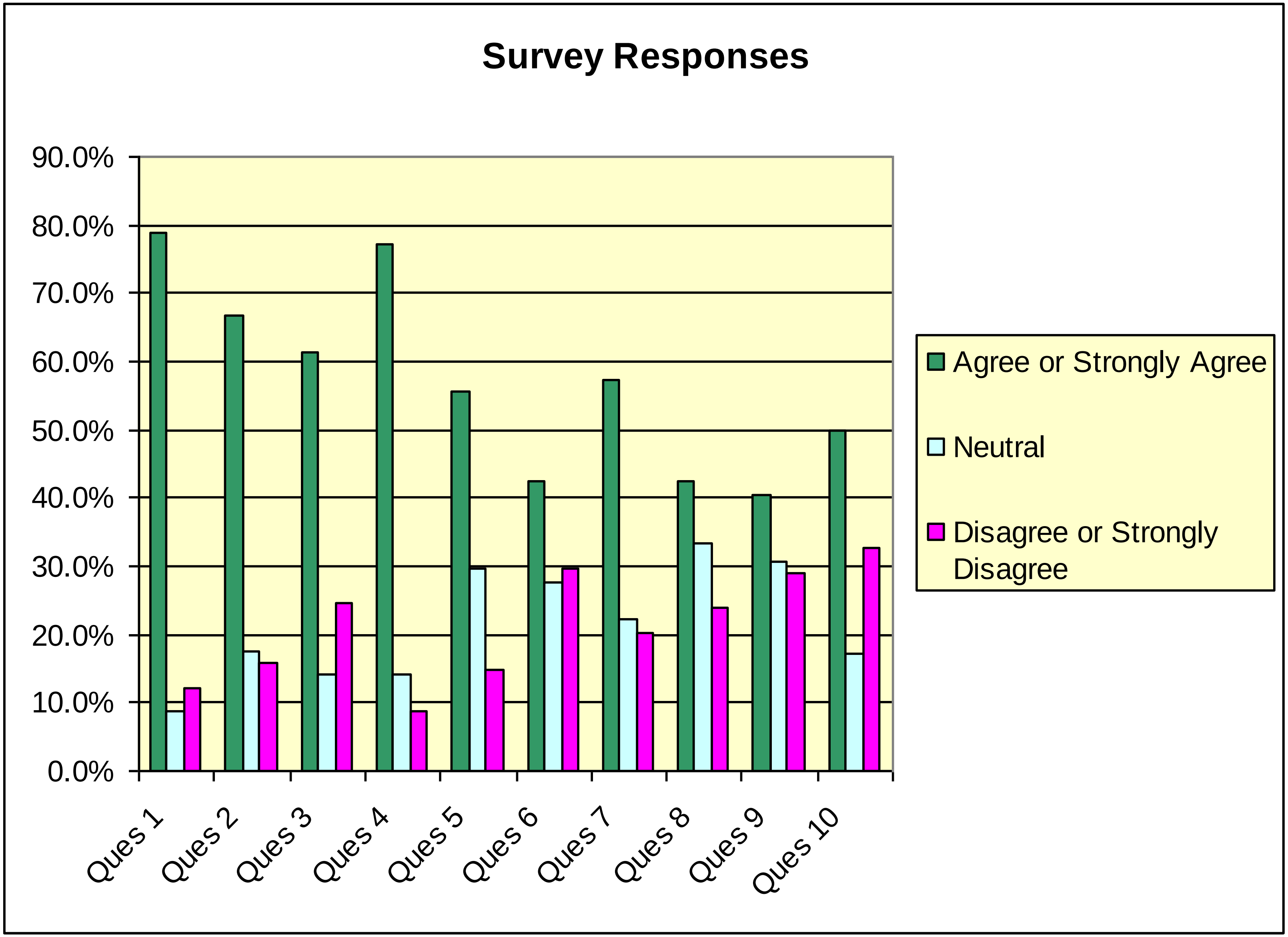
Who is working on CMMI-SVC?

- Development Team
  - Craig Hollenbach (Northrop Grumman) - Lead
  - Roy Porter (Northrop Grumman)
  - Brandon Buteau (Northrop Grumman)
  - Lynn Penn (Lockheed Martin)
  - Frank Niessink (DNV/CIBIT)
  - Jerry Simpson (SAIC)
  - Drew Allison (SSCI)
  - Eileen Forrester (SEI)
  - Barbara Tyson (SEI)
  - Eileen Clark (SRA)
- Other contributors
  - Jeff Zeidler (Boeing)
  - Rich Raphael (Mitre)
  - Joanne O'Leary (SEI)

General Survey Questions

1. The service practices that are covered in CMMI-SVC will enable service organizations to provide more effective support to their customers.
2. The material in CMMI-SVC yields a useful adaptation of CMMI best practices as they relate to service deployment.
3. The CMMI-SVC appropriately uses the CMMI framework.
4. CMMI-SVC includes process areas that must be satisfied for process improvement and institutionalization.
5. CMMI-SVC does not impose constraints (derived from the needs of a specific service or market segment) that would limit or prevent other organizations from adapting the model to their own specific needs.
6. The CMMI-SVC is easy to understand and apply to a service organization.
7. The process areas in CMMI-SVC cover all significant service-specific requirements and effectively reflect activities that a service organization should be accomplishing.
8. Additions and amplifications that exist in other models and are also used within the CMMI-SVC constellation are appropriate.
9. Notes and examples in CMMI-SVC clearly apply to service organizations and meet their specific needs.
10. References in PAs to related process areas are clear and consistently applied.

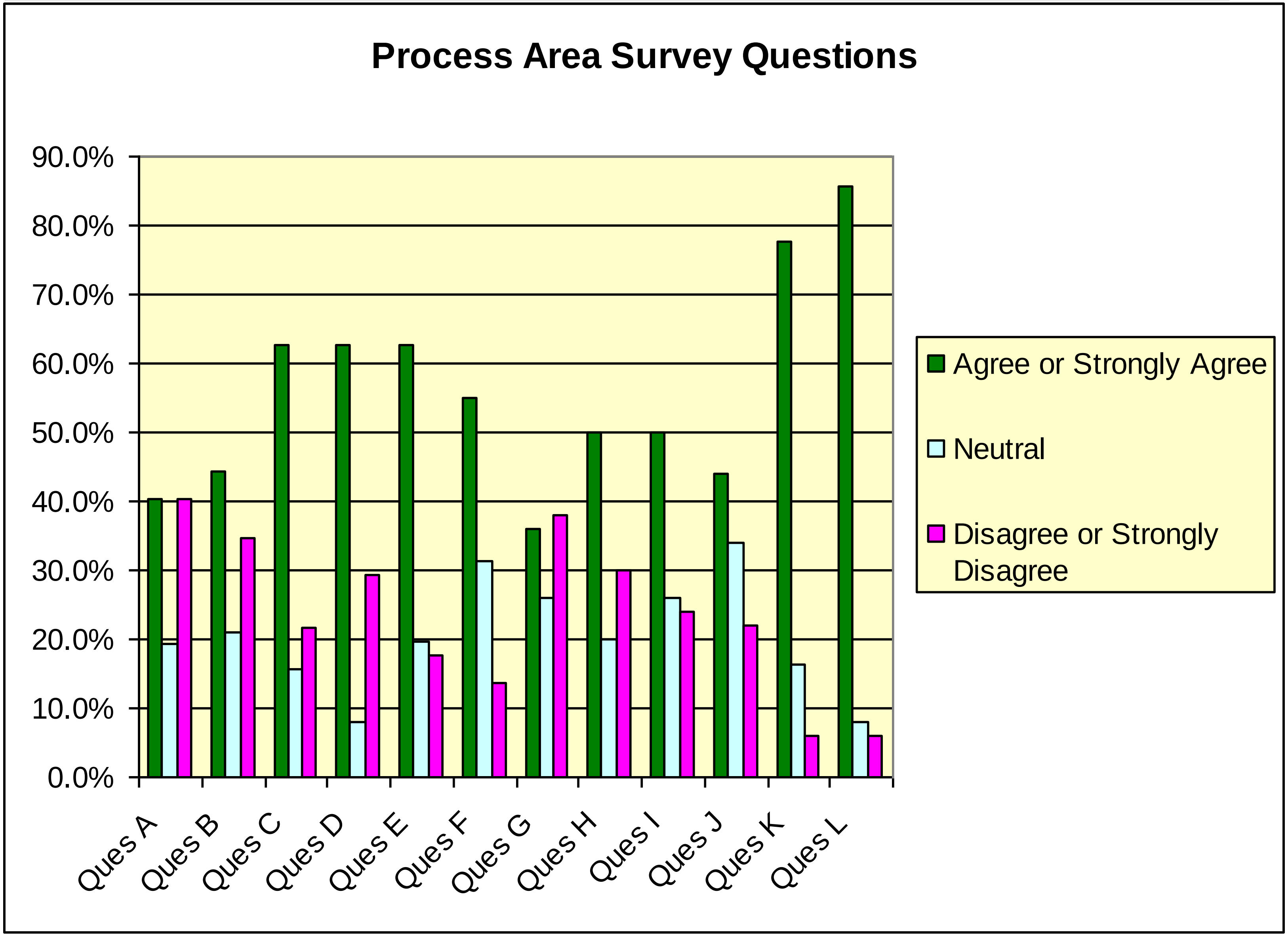
Results to General Survey



Process Area Questions

A. Problem management practices that are common within the service industry are appropriately addressed in the process area Problem Management and are distinguished from the practices in the Causal Analysis and Resolution process area.
B. The Project Management category is the most appropriate classification for the Service Continuity Management and Capacity and Availability Management process areas.
C. The Process Management category is the most appropriate classification for the Organizational Service Management process area
D. The practices within the Service Continuity process area should build upon the practices within the Risk Management process area similar to the manner in which the Integrated Project Management process area builds upon maturity level 2 project management practices.
E. The Service System Development process area must be required for an organization to be a mature service organization.
F. The specific practices in the Service System Development process areas are presented with the appropriate rigor and detail for a mature service organization.
G. The Project Monitoring and Control process area adequately addresses service level management.
H. Material about the collection of customer satisfaction information is adequately covered as a specific practice in Organizational Service Management (an optional process area) and as informative material in the Service Delivery process area.
I. Maintenance found in the Service Delivery process area is adequately differentiated from product maintenance covered by CMMI-DEV.
J. The IPPD addition is as appropriate or as applicable for CMMI-SVC as it is for CMMI-DEV and should be added.
K. The Supplier Agreement Management process area is appropriate both for organizations with tangible products and service organizations with supplier agreements solely for services.
L. The Supplier Agreement Management process area should be required to reach maturity level 2 for service organizations with supplier agreements solely for services (as it is for organizations with suppliers of tangible products).

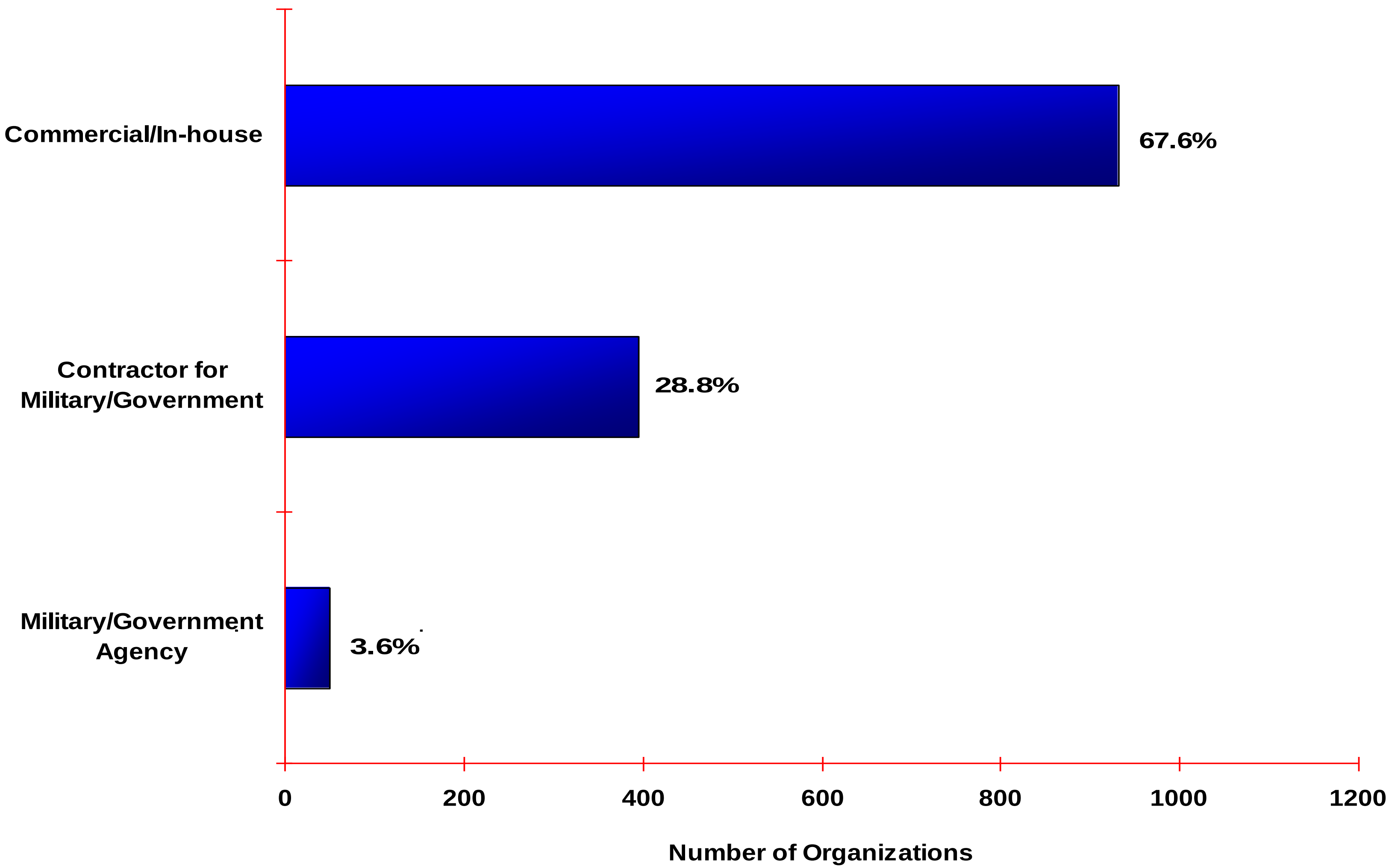
Process Area Survey Questions



What is the relationship between CMMI-SVC and ITIL?

- CMMI-SVC complements ITIL
  - Summarizes ITIL best practices into a small set of specific practices.
  - Reuses about 80% of the current CMMI model, allowing users to leverage their investments in development-based process training, improvements, and infrastructure to service-based offerings.
  - Provides an industry-accepted maturity model, helping organizations to plan and track their incremental progress toward high maturity.
  - Uses the same SCAMPI appraisal method that is used with the current CMMI model, allowing organizations to leverage appraisal expertise, preparation methods, and selected artifacts.

Who uses CMMs?



Courtesy of the SEI

Why do CMMs *really* matter?

Improvements	Median	Data Count	Low	High
Cost	34%	29	3%	87%
Schedule	50%	22	2%	95%
Productivity	61%	20	11%	329%
Quality	48%	34	2%	132%
Customer Satisfaction	14%	7	-4%	55%
ROI	4.0 : 1	22	1.7 : 1	27.7 : 1

- N = 30, as of August 2006
- Organizations with results expressed as change over time

Courtesy of the SEI

Revitalizing Education and Training in Systems Engineering

Don S. Gelosh, PhD

Sr. Systems Engineer

Office of Deputy Director for Enterprise Development

Systems and Software Engineering

Office of the Deputy Under Secretary of Defense (A&T)

Outline

- Mission Statement
- Systems Engineering Policies
- Education and Training
- Systems Planning, Research, Development, and Engineering (SPRDE) Career Field Update
- Core Plus
- The Way Ahead…

Systems and Software Engineering Mission Statement

- Shape acquisition solutions and promote early technical planning
- Promote the application of sound systems and software engineering, developmental test and evaluation, and related technical disciplines across the Department's acquisition community and programs
- Raise awareness of the importance of effective systems engineering and drive the state-of-the-practice into program planning and execution
- Establish policy, guidance, best practices, education, and training in collaboration with academia, industry, and government communities
- Provide technical insight to program managers and leadership to support decision making

Driving Technical Excellence into Programs!

System Engineering Policies

All programs shall develop a SE Plan (SEP)

Each PEO shall have a lead or chief systems engineer who monitors SE implementation within program portfolio

Event-driven technical reviews with entry criteria and independent subject matter expert participation

OSD shall review program's SEP for major acquisition programs (ACAT ID and IAM)

Technical Planning

Technical Leadership

Technical Execution

Technical Excellence

Strong technical foundation is the value of systems engineering to the program manager

What's Coming in Policy

- **Codified SE revitalization in DoDI 5000.2**
  - Captures previously approved SE and related policies
  - Mandates SEP at Milestones A, B, and C
  - Considers SE during Concept Refinement and Technology Demonstration phases
  - Mandates system-level Critical Design Review, sets CDR exit criteria, requires a CDR report to Milestone Decision Authority
  - Establishes functional, allocated, and product baselines during SDD
  - Mandates Program Support Reviews for all MDAPs
  - Establishes requirement for Configuration Management and Data Management strategies

SE in Defense Acquisition Guidebook

- SE guidance to acquisition community—Chapter 4
  - Best practices for “applied” SE
    - SE processes (8 technical management, 8 technical)
    - Guide for each acquisition phase, concept refinement through disposal
  - Linkage of SE products and processes to acquisition objectives and decision points
  - Currently being updated

http://akss.dau.mil/dag/welcome.asp

Education and Training

Education &Training Background

- In October 2003, an Education and Training Summit found that while SE processes were sound, their application in acquisition programs was often lacking in rigor.
- Among other initiatives, the Director, DS/SE, (now SSE/ED) issued a directive to re-baseline the SE competencies and curriculum for the SPRDE/SE career path.
- The SPRDE/SE FIPT, working with the Institute for Defense Analysis, developed almost 200 learning outcomes to serve as a basis for the new curriculum.
- The new curriculum was structured to focus on the 16 DoD SE processes at Level I, 5 SE phases at Level II, and leadership and management skills at Level III.
- From August 2004 until February 2007, DAU developed four new courses: SYS 101, SYS 202, SYS 203, and SYS 302.

Education & Training (SYS 101)

- **SYS 101: Fundamentals of Systems Planning, Research, Development and Engineering**
  - **Technically rigorous, comprehensive online course that provides an introduction to systems engineering.**
  - **Based around the 8 technical management processes and the 8 technical processes outlined in the Defense Acquisition Guidebook.**
  - **Also suitable for personnel in technical management and program management positions who want to understand more about systems engineering and the details of its processes.**

Education & Training (SYS 202)

➢ **SYS 202: Intermediate Systems Planning, Research, Development and Engineering, Part I**

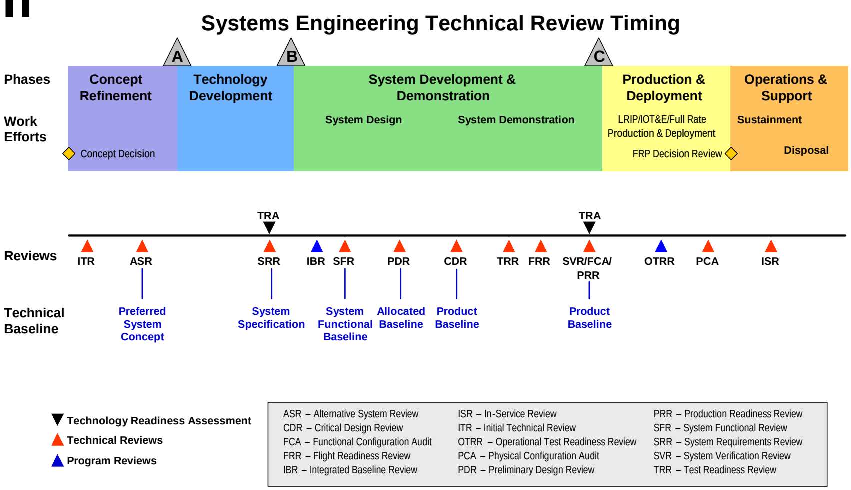
- **Intermediate-level online course that provides a description of how the SE processes can be applied within the context of the various phases of the Defense acquisition framework.**
- **Course content includes the scope and role of SE and its key technical inputs and outputs;**
  the key aspects of technical baselines
  and the role of technical reviews;
  and important design considerations.

Education & Training (SYS 203)

➢ SYS 203: Intermediate Systems Planning, Research, Development and Engineering, Part II

- Intermediate-level 1-week long classroom course that requires students to apply the DoD Systems Engineering processes and techniques learned in SYS 101 & SYS 202.

- Students work in integrated product teams and apply systems engineering technical processes and technical management processes to a defense system across the various phases of the Defense acquisition framework.

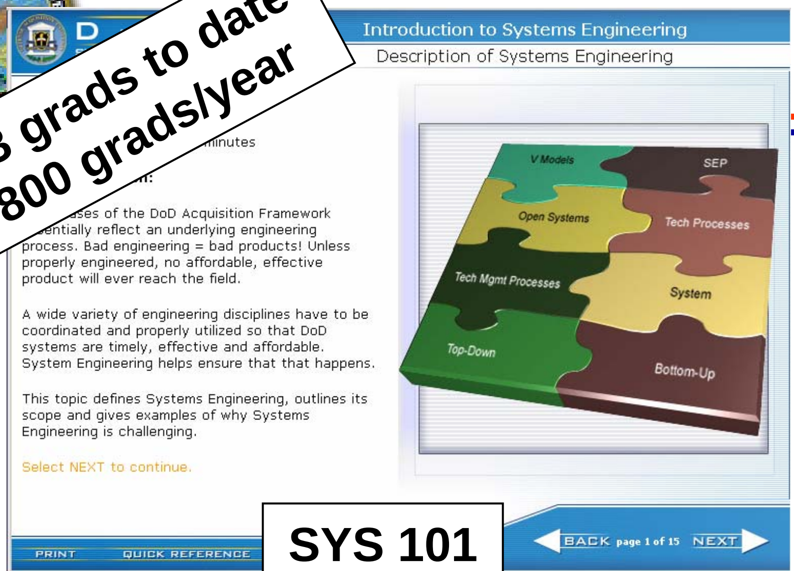


Education & Training (SYS 302)

➢ SYS 302: Technical Leadership in Systems Engineering

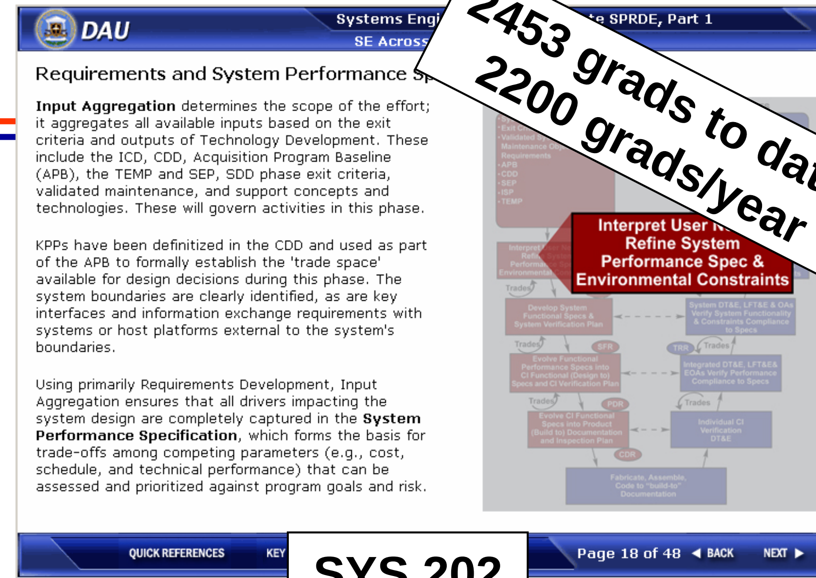
- **Advanced 2-week long classroom course designed for senior DoD acquisition personnel.**
- **Focuses on the application of technical leadership skills within a typical DoD SE IPT environment.**
- **Students take turns leading and participating in an engineering team that analyzes and resolves a variety of technical engineering critical issues.**
- **Class exercises are supplemented by lessons on current policy, architectures, design considerations, ethics, etc.**

7043 grads to date*
7800 grads/year



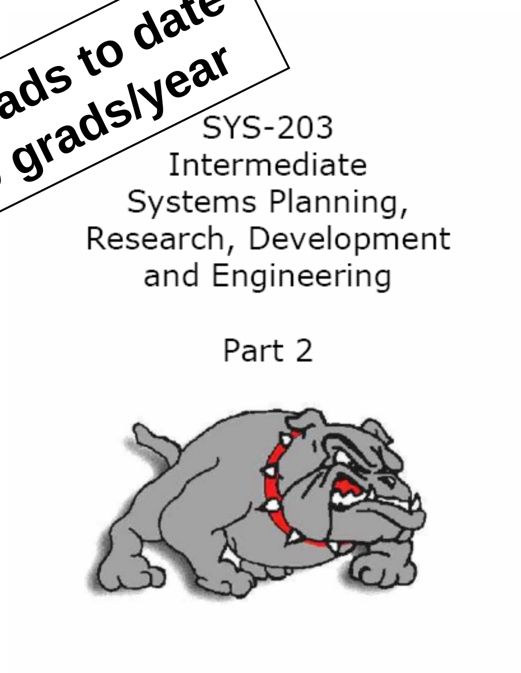
SYS 101

2453 grads to date*
2200 grads/year

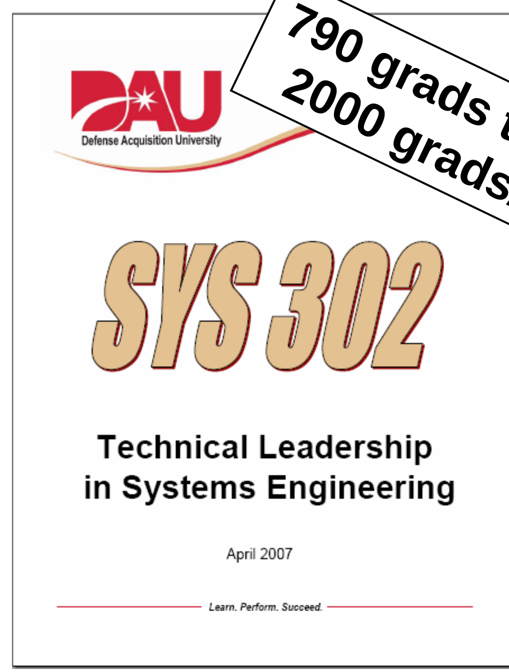


SYS 202

1451 grads to date*
2100 grads/year



790 grads to date*
2000 grads/year



*as of
Sep 10, 2007

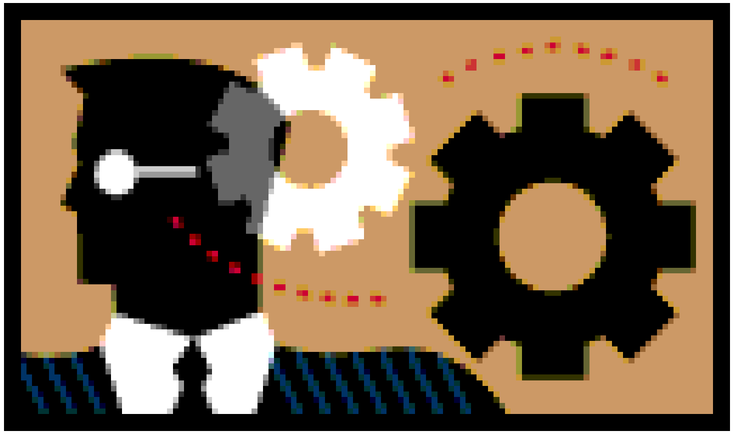
Education & Training (LOG 204)

- **LOG 204: Configuration Management**
  - Fast-paced, cross-disciplinary course that provides the knowledge necessary to apply configuration management (CM)
  - Includes the interrelationship of CM to such life cycle activities as systems engineering, data management, logistics support planning, and weapon system sustainment.
  - Provides an overview of the concepts and basic practices of CM, including configuration identification, status accounting, audits and verification, configuration change management, performance measures, and CM planning.

Education & Training (CLMs)

- **CLE 003: Technical Reviews**
  - Presents essential practical guidelines for integrating several different technical reviews into the systems engineering process and DoD acquisition life cycle based on best engineering practices.
- **CLL 008: Designing for Supportability in DoD Systems**
  - Provides a comprehensive overview and introduction to incorporating the principles of systems engineering throughout the system life cycle to design, develop, produce, and sustain operationally reliable, supportable, and effective systems.
- **CLE 017: Technical Planning (Proposed standard for FY 09)**
  - Presents essential and practical technical planning guidance on how to integrate program management tools, such as earned value management and risk management, with systems engineering tools like requirements management, technical baseline management, and event-based technical reviews into an effective approach for managing programs.

SPRDE Career Field Update



SPRDE Career Field Update Background

- Based on the new SYS curriculum and the FIPT Chair's proposal to enhance certification requirements, the SPRDE/SE FIPT began revising certification standards and Position Category Descriptions.

- A proposal was vetted to create an additional career path to provide maximum flexibility in implementing the new standards:

  - Original career path would retain the 1, 2, 4 years of experience and similar certification standards.

  - Additional career path would encompass 2, 4, and 8 years of experience and enhanced certification standards.

- The Acquisition Workforce Senior Steering Board accepted this proposal in August 2006 and the implementation details were worked out and resulted in an agreement in February 2007.

Implementation Details

- **New career path, “SPRDE/PSE (Program Systems Engineer)”, with a new position code and position category description was established on October 1, 2007.**
- **Targets PEO Chief/Lead Engineer and Program Systems Engineer positions. Requires more years of experience and more training.**
  - ***Components are in the process of recoding positions.***
- **No change to existing career path, “SPRDE/SE (Systems Engineering)”.**
  - ***No impact on current SPRDE/SE certification standards.***

New SPRDE/SE & /PSE Career Paths Certification Standards

SPRDE-Systems Engineering

LEVEL I (1 Years)
- ACQ 101
- SYS 101

LEVEL II (2 Years)
- ACQ 201A
- ACQ 201B
- CLE 003
- SYS 202
- SYS 203

LEVEL III (4 Years)
- CLL 008
- SYS 302

SPRDE-Program Systems Engineer

LEVEL I (2 Years)
- ACQ 101
- SYS 101
- Two additional Level 100 courses from a variety of disciplines
- XXX 101
- AND
- XXX 101

LEVEL II (4 Years)
- ACQ 201A/B
- CLE 003
- SYS 202
- SYS 203
- LOG 204 (CM) + one additional Level 100 or 200 course from a variety of disciplines
- LOG 204
- XXX 101
- OR
- XXX 201

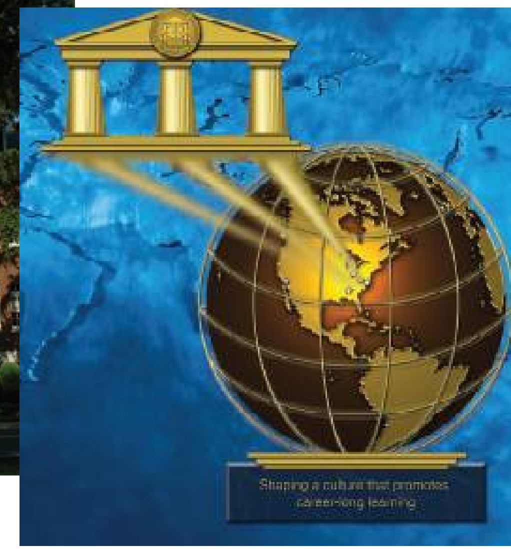
LEVEL III (8 Years)
- CLL 008
- SYS 302
- Two additional Level 200 or 300 courses from a variety of disciplines
- XXX 201
- AND
- XXX 301

Legend:
- Existing
- New
- Additional

Side-by-Side
DoD SPRDE/PSE vs. INCOSE CSEP

	DoD SPRDE/PSE	INCOSE CSEP
Levels	Three levels	Only one level
Education	Bachelors or graduate degree in a technical or scientific field such as engineering, physics, chemistry, biology, mathematics, operations research, engineering management, or computer science.	Bachelor's degree/equivalent in technical field (Additional experience must be substituted for non-technical degree) 5 more years of engineering for non-technical Bachelor's (total 10 years) 10 more years of engineering if no Bachelor's degree (total 15 years)
Experience	Level I: 2 years of technical experience from specified career fields Level II: 4 years of technical experience from specified career fields (in acquisition position) Level III: 8 years of technical experience from specified career fields (in acquisition position)	5 years minimum in multiple SE disciplines
Training	Several acquisition, systems engineering, and elective courses from the Defense Acquisition University (DAU), based on level	Only what is needed to pass the exam
Recommendations	None	At least 3 Colleagues/Peers/Managers who are knowledgeable in Systems Engineering
Examination	None (Exams and assessments contained in individual DAU courses.)	Certification exam, based on current INCOSE SE Handbook. Each exam costs $80.
Renewal	None	3 year renewal 120 Professional Development Units required during prior 3 years Renewal Application and Fee is $100 – discounted to $50 for INCOSE member Continuing education log required
Certification Cost	None	Application fee is $400 – discounted to $300 for INCOSE members

Core Plus



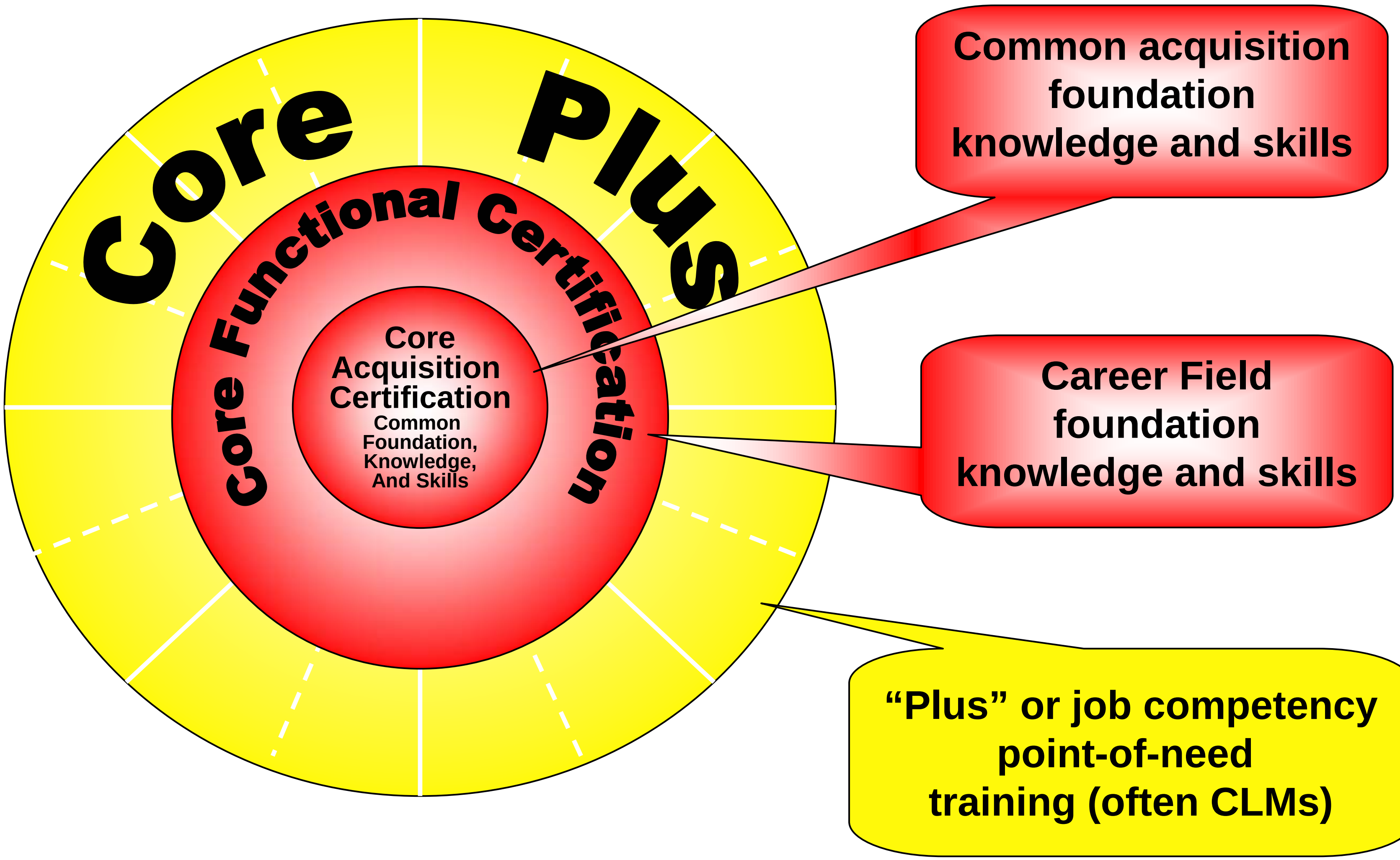
What is Core Plus?

Core Plus is an <u>enhancement</u> to the AT&L certification framework.

Core Plus is designed to <u>help guide</u> workforce members to additional training beyond that required for certification.

Core Plus Video:
http://view.dau.mil/dauvideo/view/eventListing.jhtml?eventid=1583

Core Plus Target



Core Plus Development Guide
Example for SPRDE-SE Level II

Core Plus Development Guide [3]	Type of Assignment			
Training [2]	Funct Spec	Software / IT Eng	Dev Eng	S&T Eng / Sci
IRM 201: *Intermediate Information Systems Acquisition* **CR**		X		
LOG 200: *Intermediate Acquisition Logistics, Part A*	X		X	
LOG 203: *Reliability and Maintainability*	X		X	
PQM 201A: *Intermediate PQM Part A*		X		
SAM 201: *Intermediate Software Acquisition Management* **CR**		X		
STM 201: *Intermediate S&T Management* **CR**				X
TST 202: *Intermediate Test and Evaluation* **CR**	X	X	X	X
CLB 016: *Intro to Earned Value Management*	X	X		
CLB 017: *Performance Measurement Baseline*	X	X		
CLC 041: *Predictive Analysis and Systems Engineering*	X	X		
CLE 007: *Lean 6 Sigma*	X	X	X	
CLE 016: *Outcome-based Performance Measures*	X	X		
CLE 017: *Technical Planning*	X	X	X	X
CLE 020: *Enterprise Architecture*	X	X	X	X
CLM 101: *Analysis of Alternatives*	X	X		X
CLM 029: *Net-Ready Key Performance Parameter (NR-KPP)*	X	X	X	X
CLM 031: *Improved Statement of Work*	X	X	X	X
CLM 032: *Evolutionary Acquisition*	X	X	X	
Education				
Graduate degree in a discipline such as engineering, physics, chemistry, biology, mathematics, operations research, engineering management, or computer science.				
Experience				
2 additional years of technical experience.				

Core Plus Benefits and Challenges

Benefits:

- Core Plus advances the AT&L Competency Management Model:
  - The right learning – better focus
  - The right people – focused on competency needs
  - The right time – better connection to job needs
  - Keeps the 3-level certification framework

Challenges:

- To make it work, Core Plus requires:
  - Increased Supervisor-Employee interaction
  - More emphasis on Individual Development Plans
  - Senior leadership support

The Way Ahead for SE E&T…

- Keep curriculum up to date and properly aligned with revised policies and guidance.
- Establish two-way communications with the SE workforce through outreach and feedback.
- Enhance SE Communities of Practice / Websites.
- Work with academic institutions and universities on equivalency issues (i.e., AFIT & NPS).
- View education and training as both catalyst and facilitator for cultural change.

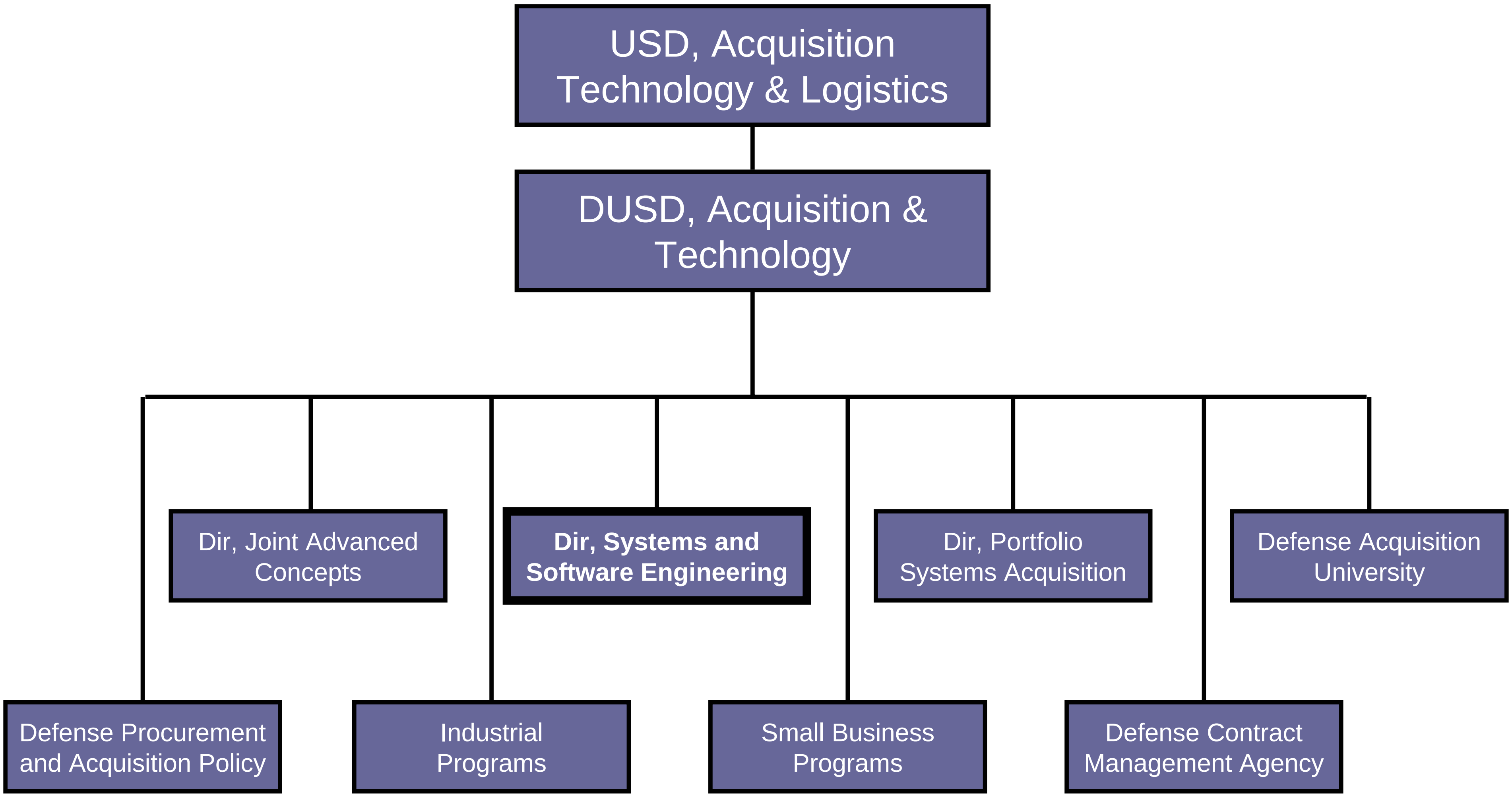
Questions?

Questions for Discussion

- How do you facilitate Cultural Change?
- How do you get past the "Certification Checklist" mentality?
- How do you assess the SE workforce?
- How do you determine if education and training efforts are achieving desired outcomes?
- How do you keep the SE workforce current?
- What would you put into a 400-level SYS course?

Backup

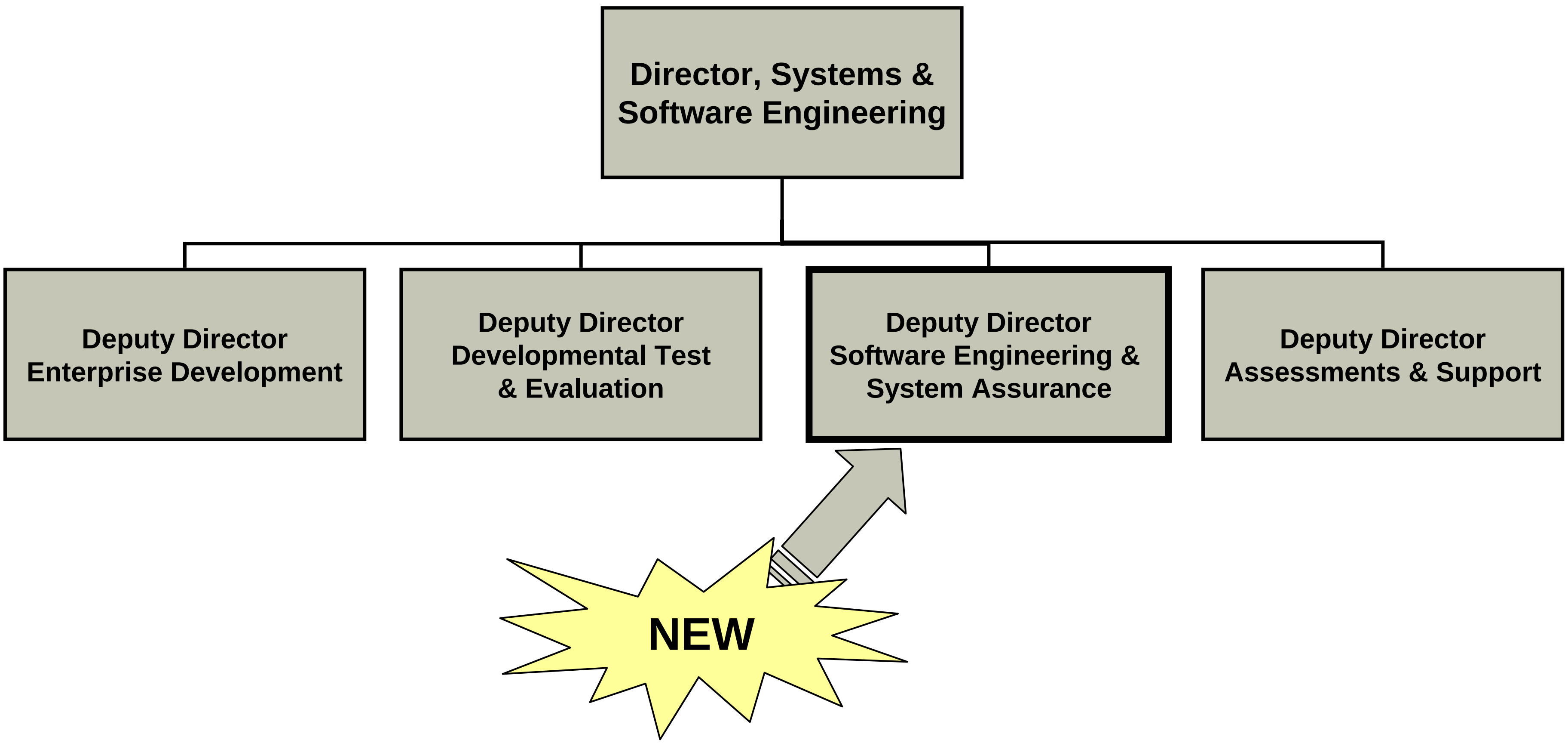
OUSD (AT&L) Organization



Flatter, Leaner, Empowered!

Systems and Software Engineering

An Organizational Construct



Management Visibility – Best Practices – Acquisition Excellence

What We Have Done To Revitalize Systems Engineering

- Issued DoD-wide SE policy – focused effort on up front, sound technical planning; issued safety policy
- Issued guidance on Systems Engineering, test and evaluation (T&E), software, and safety
- Worked with Defense Acquisition University to revise Systems Engineering curricula -- currently revising T&E and enabling career fields curricula
- Established Systems Engineering Forum—senior-level focus within DoD
- Integrated development testing, software/system assurance, system of systems, and open systems into revitalization efforts
- Instituting a renewed emphasis on modeling and simulation
- Leveraging closer working relationships with industry and academia
- Instituting system-level assessments in support of OSD major acquisition program oversight role

Much Accomplished – Much to Do!

Systems Engineering Plan Trends

- What's working:
  - Programs beginning to establish SE WIPTs early in the life cycle to develop and document their technical planning
  - Increased Program Executive Office level Lead/Chief Systems Engineers involvement in SEP development
  - Movement to event-driven versus schedule-driven programs
    - More focus on entry and exit criteria for technical reviews
- What needs work:
  - Firming up technical planning prior to RFP release
  - Proposed processes for a program not always tailored to fit program
    - Often appear to be copied from a manual or guide.
  - SEP author is someone in program office (contractor or junior person) who is not familiar with the technical strategy.
  - SEPs need to be consistent with key program documents

What's Next?

- We have revitalized Systems Engineering Policy, Guidance, Education and Training…
- We have driven good systems engineering practices back into the way the acquisition community does business, and have had a positive impact on programs…
- We have expanded the boundaries to include increasingly important enablers for sound SE application…
- We have a rigorous process to capture what went wrong...
- …**but failed to change,** root cause behavior that leads to programs that do not meet cost, schedule, and performance expectations…adequate maturity at program initiation

Much Accomplished – Much to Do!

Transforming USCG Logistics

A systems engineering approach to transforming the USCG Enterprise Logistics Systems

Patrick W. Cumby
Director Performance Systems
VectorCSP

www.vectorcsp.com

Agenda

- USCG Logistics Transformation Background
- Enterprise Transformation Basics
- USCG Logistics Transformation
- Demos of Logistics Models and Transition Dashboards

Logistics Transformation Background

- USCG has several “stovepiped” logistics business models (surface, air, shore, IT)
- Models have evolved over time and are not integrated or strategically aligned
- Some of the various models utilize modern logistics concepts, others do not
- Limited visibility into systems performance
- Limited ability to manage costs and effectiveness
- ***Then along comes the Deepwater program, the CFO Act, and Katrina…***

Logistics Transformation Drivers

- Deepwater program – recapitalization of USCG assets and capabilities
  - Deepwater program has experienced several issues that have led to a major restructuring of the program.
- CFO Act – Mandate to institute total asset visibility and financial controls
- Success of Katrina disaster response – demonstrated strengths of USCG Aviation logistics model

Logistics Transformation Objectives/Scope

- **Admiral Allen issues CIAO #4**
- Bi-level maintenance w/more standardized procedures.
- Centralized supply chain management w/spending driven by maintenance requirements.
- *Disciplined/standard Coast Guard-wide engineering and logistics business processes, modeled after our internal best practices currently in use in aviation.*
- Strong configuration management processes, w/associated compliance inspections, to ensure all configurations are safe, effective, and supportable when installed.
- Reduce the number of financial and information systems.

Transformation Support Team

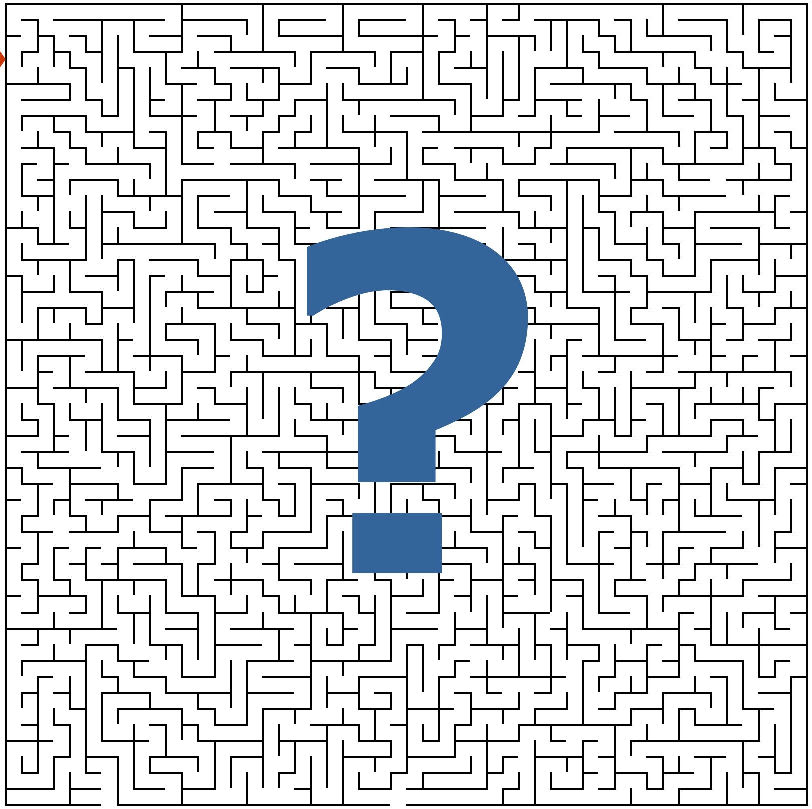
- Logistics Transformation Program Integration Office (LTPIO) established
- General Dynamics contracted to provide program management
- VectorCSP contracted to support organizational and logistics transformation

Transformation Management Approach

- LTPIO chose VectorCSP's Pathfinder approach to develop the logistics business model
- Pathfinder is a systems-oriented, tools-based transformation management methodology
- Pathfinder incorporates a complete business systems performance model, with an emphasis on behavioral engineering

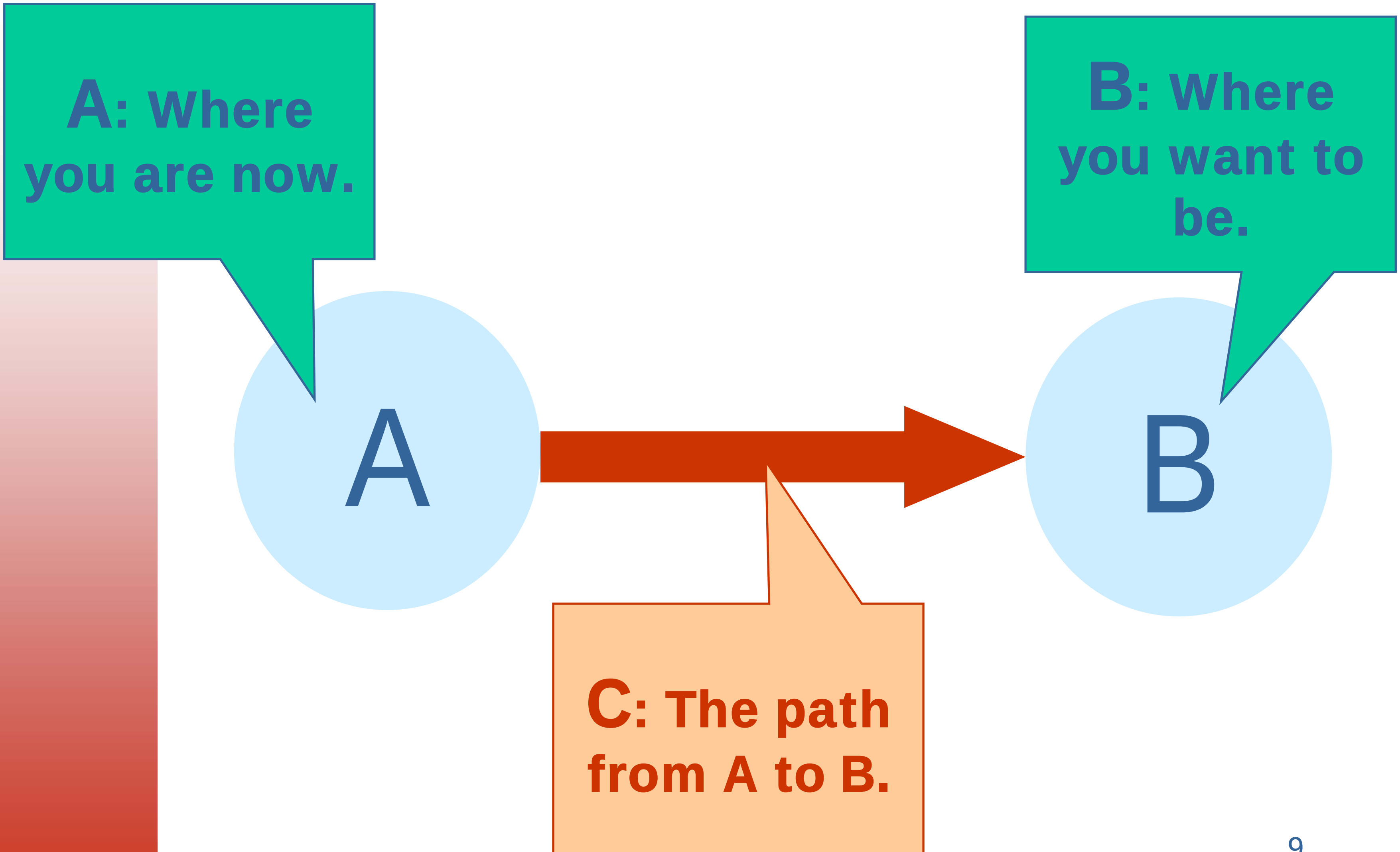
Let's go back to Org Transformation Basics!

Start Here



Finish!

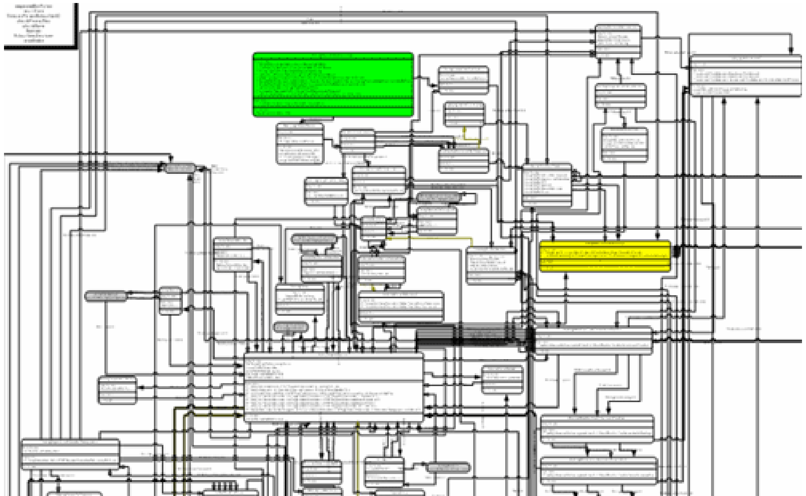
Enterprise Transformation ABCs



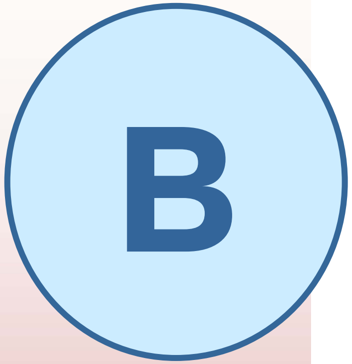
A: Where you are now.

- In order to get from **A** to **B**, you have to understand **A**.
- **A** is your “As-Is” organizational and business model
- **A** is usually very, very complex...

Usually the important cultural and political aspects of a business model are not well documented.

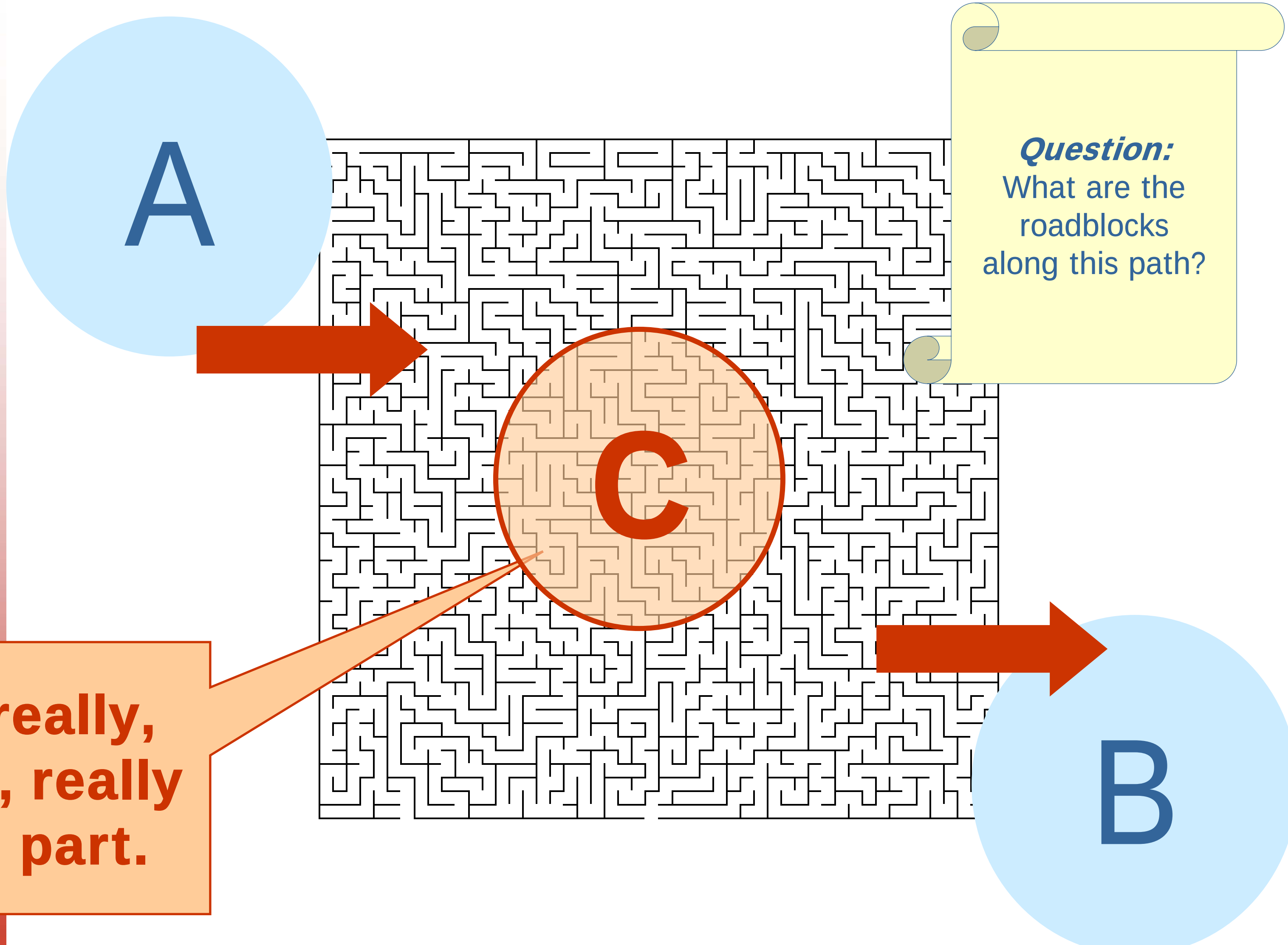


B: Where you want to be.



- In order to get from **A** to **B**, you also have to understand **B**.
- **B** is your "To-Be" organizational and business model
- **B** is usually not well defined...

C: The Path from A to B



Question:
What are the roadblocks along this path?

The really, really, really hard part.

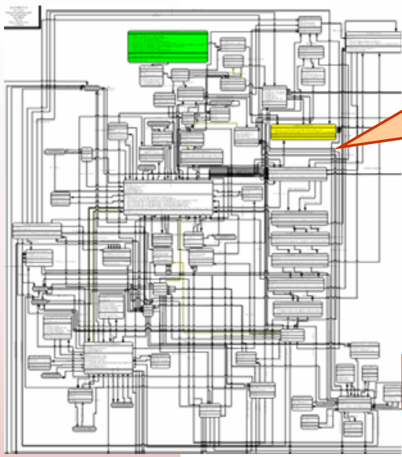
Speedbumps on the Path

- Strategic Alignment
- Technology
- Process
- Organizational Design
- Culture
- Politics

Question:
Of these roadblocks, which is most difficult to overcome?

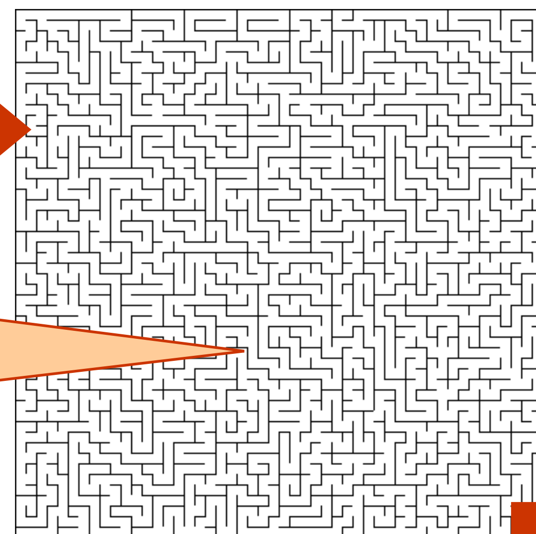
Path from A to B

To sum it up...

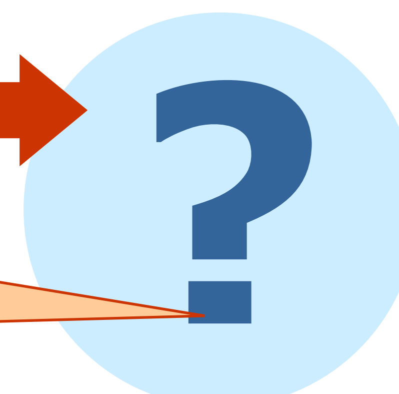


You move from a highly complex (and usually broken) system...

Question:
What percentage of enterprise transformations succeed?



...through a complex transformation process fraught with cultural, technical, and political barriers...



...to get to what is usually a poorly understood end state.

It’s no wonder that

85%

of all enterprise transformations

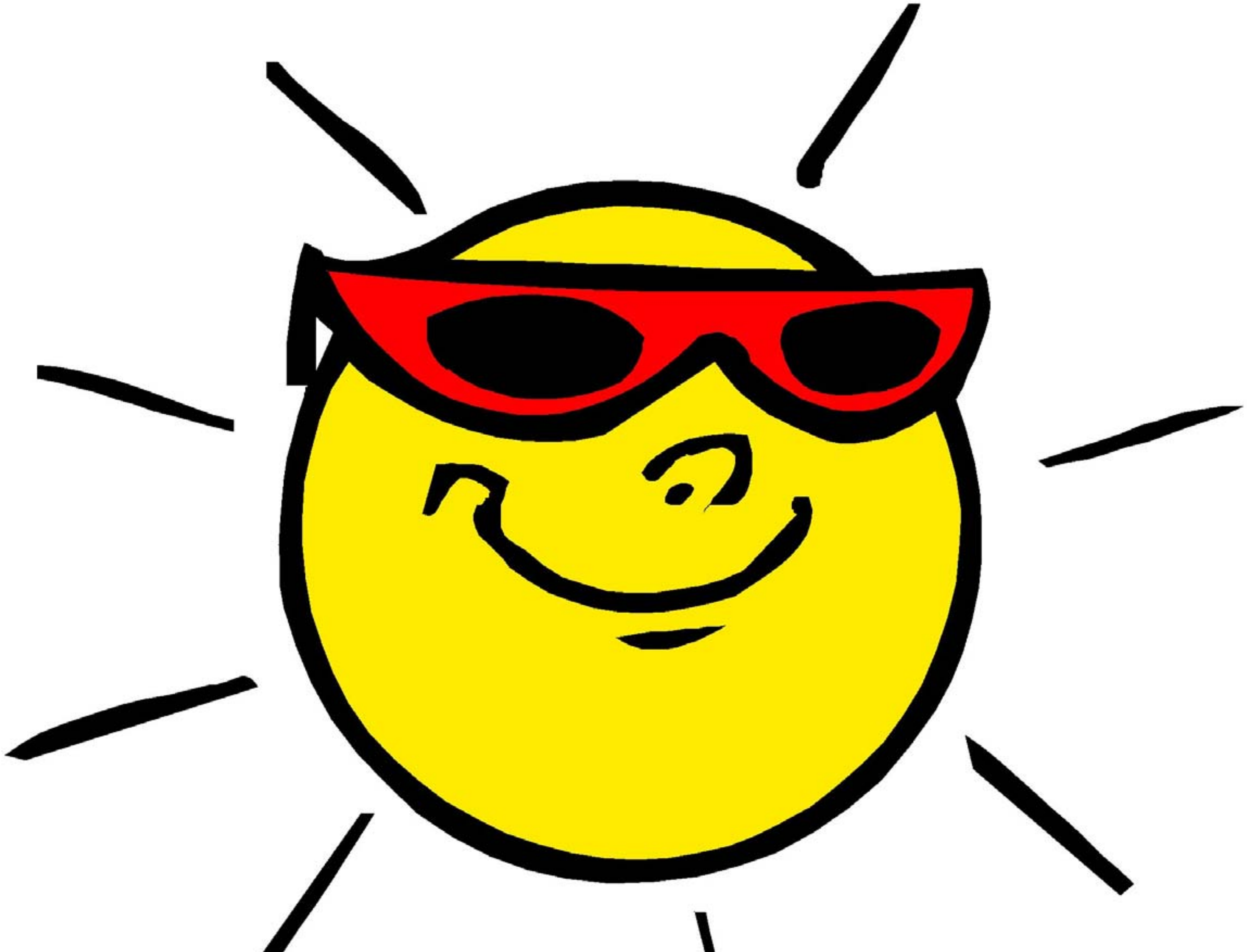
Do not fully succeed!

What you need to succeed

1. Clearly defined transformation **objectives**
2. A way to identify **A** and **B**
3. A roadmap to transform the **structures**, **processes**, **technology**, **culture** and **politics** of the organization
4. A way to manage the **astounding complexity** and **mountains of data** of such a large-scale endeavor
5. A way to **communicate** with all stakeholders
6. A way to **measure success** of the transformation
7. A **fully-dedicated** transformation management team

In other words...

...you need a systems engineering approach!



The Coast Guard Logistics Transformation

Start Here

Finish!

vector/CSP

Coast Guard Transformation

A: Separate logistics models for surface and aviation.

C: Logistics Transformation.

B: Standard logistics model based on aviation model.

A

Current State

Path from A to B

B

Desired State

A: The “As-Is” State of CG Logistics

A

- Multiple logistics models (naval, aviation, shore, C4ISR)
- Problematic logistics systems for naval, shore, and technology systems
  - Non-standard fleet assets and inventories
  - Antiquated logistics processes and technology
  - Sub-optimal acquisition model
  - Poor financial controls
- Not compliant with CFO Act
- Problems with Deepwater program
- Getting the mission accomplished despite sub-optimal logistics systems due to dedication and “can-do” attitude

B: The "To-Be" State of CG Logistics

B

- Adopt CG Aviation Integrated Logistics Systems (ILS) model
- Standard fleet assets and Total Asset Visibility
- Integrated technology infrastructure (based on modified ALMIS)
- Transparent and tightly controlled financials
- CFO Act Compliance
- Systems measures of effectiveness (MOEs)

C: The Path to Transition

C

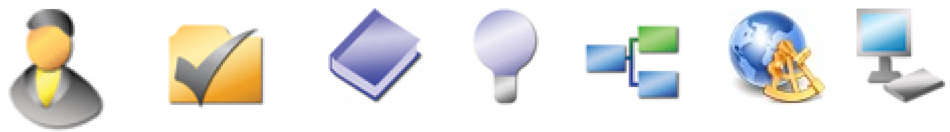
- Commandant's CIAO establishes transformation objectives
- LTPIO established as the **fully-dedicated transition team**
- **Pathfinder Performance Modeling** approach chosen by LTPIO as a key transformation management tool.

About Pathfinder

- Pathfinder is a dedicated **transformation modeling** and support system
- Designed for **large-scale** organizational transformations
- Pathfinder is based upon a **systems engineering** approach to org transformation

Performance System Engineering

- Pathfinder breaks organizational performance into discrete systems elements



...

- It incorporates **process engineering**, **organizational design**, **enterprise architecture**, and most importantly **behavioral engineering**
- It enables modeling of all elements that **influence** organizational performance
- It makes it possible to manage the complexity of a large transformation

Performance Systems Components

- **Key building blocks of a Performance Model**

System

System Outcome

Job Role or Team (People)

Strategic Objective

Policy

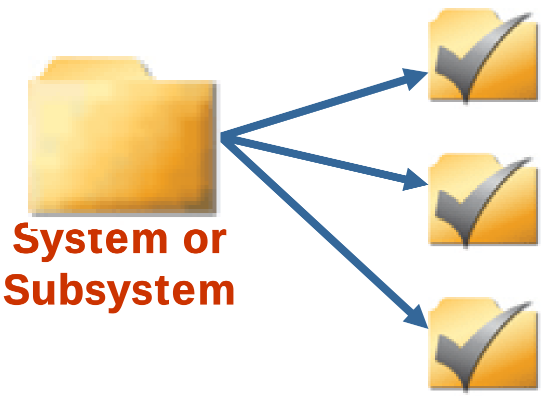
Technology

Organization

Question:
Which of these elements
is most critical to performance,
yet most often overlooked?

Performance Model Basics

A performance system can have multiple subsystems



A performance system is defined by its System Outcomes

The Outcome is the central element of a performance model

Examples of Systems and Outcomes

- The Coast Guard logistics performance model is based on the standard ILS (Integrated Logistics System)
- *Excerpt from the CG model:*

- **ILS**
  - **Maintenance**
  - **Supply**
    - **Cost driver components identified**
    - **Part enrolled in ALMIS**
    - **Level of Repair determination**
    - **Many others…**

vector/CSP

Coast Guard ILS System Hierarchy

Design Interface

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Maintenance

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Manpower

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Supply

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Support Equip.

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Tech Data

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
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Finance
Vendor/OGA Contracts

Training

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

IT

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

PHS&T

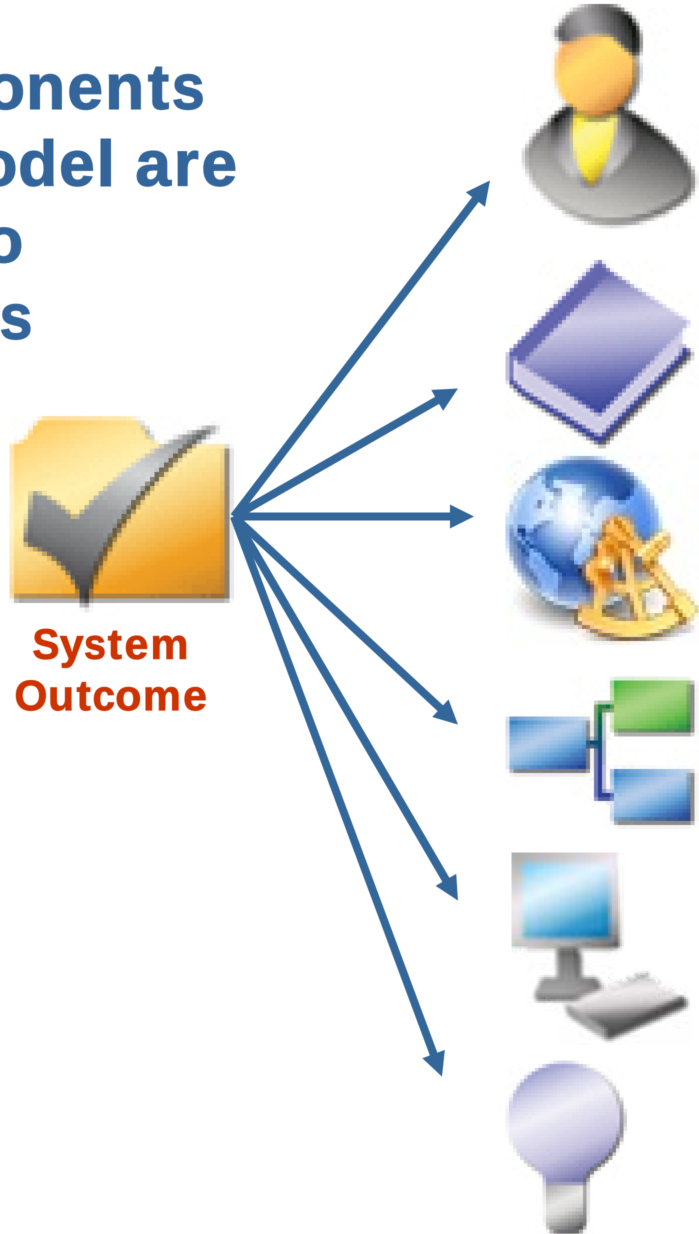
Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Facilities

Ops
Manpower
Facilities
Training
Tools/Equipment
Info Management
Tech data
Environment/Hazmat
CM/Standardization
Safety
Comms/Feedback
Finance
Vendor/OGA Contracts

Performance Model Relationships

All components of the model are related to Outcomes



What job roles are involved in producing the outcome?

What policies are related to the outcome?

What strategic objectives does the outcome support?

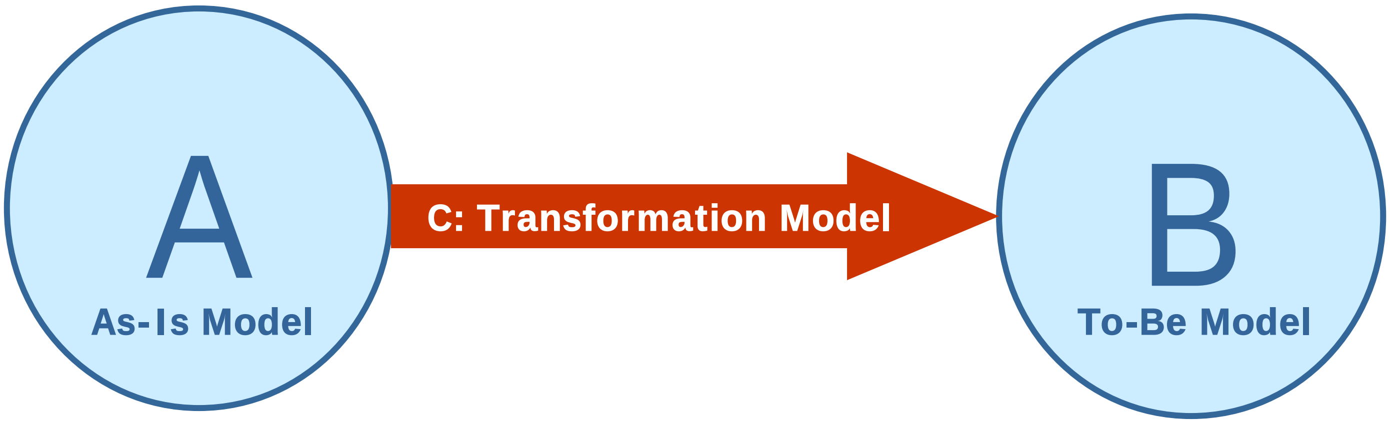
What organizations are involved in producing the outcome?

What technology is involved in producing the outcome?

What systems are related to the outcome?

Modeling A and B for CG Logistics

- This "performance modeling" approach is used to create as-is (**A**) and to-be (**B**) models of CG logistics



- *The next step is to develop the Logistics Transformation Model (**C**)*

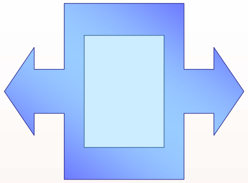
vector/CSP

Outcomes as Key Transformation Drivers

“To-Be” System Outcome

- In the Pathfinder transformation model, system outcomes are the **key transformation drivers**.
- *In other words,* ***if the “to-be” outcome can be achieved****, then the transformation to that part of the system is considered a* ***success***

Eliminating Outcome Performance Gaps

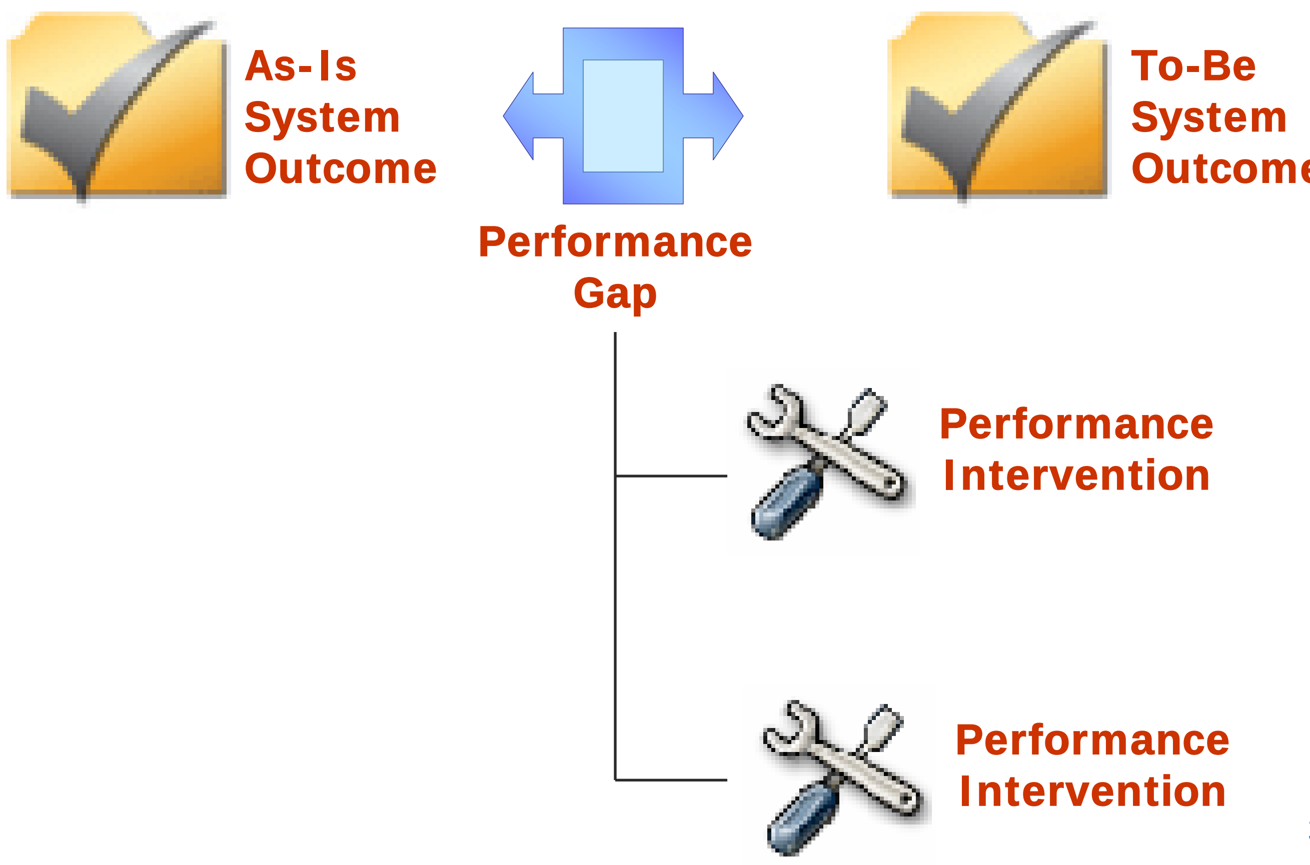


Performance Gap

- There are typically **gaps** between an **as-is** outcome and the **to-be** outcome
- These gaps are recognized in our model as a **performance gap** element
- Some gaps are simply differences in processes or personnel
- Other gaps may require technology, infrastructure, or organizational changes to eliminate
- These gaps must be eliminated by actions called **performance interventions**

Elements of the Transformation Framework

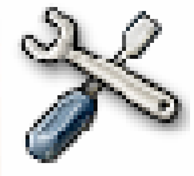
- Pathfinder includes **gaps** and **interventions** as discrete elements of the transformation model



Coast Guard Intervention Examples

- **Outcome: Approved Maintenance Procedure Card produced IAW COMDINST xxx.x**
  - **Gap: Maintenance Requirements List (MRL) not defined for surface assets**
    - Intervention: Perform MSG-3 logic analysis
    - Intervention: Enroll asset in ACMS
    - Intervention: Modify MPC process guide
    - Intervention: Identify and train MPC production staff

About Interventions



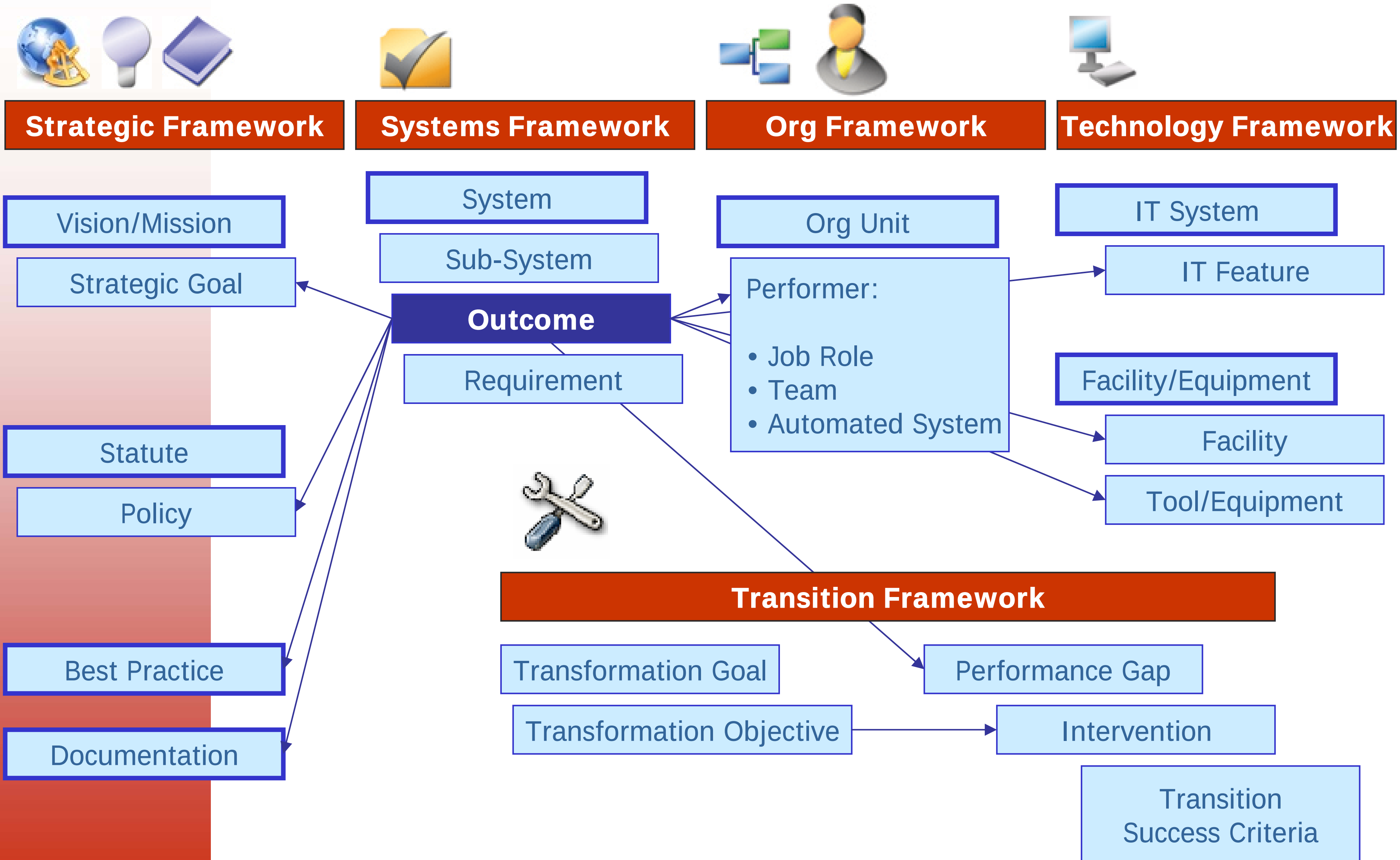
Performance Intervention

- Each intervention:
  - Is an actionable item
  - Has an accountable owner
  - Has schedule constraints
  - Has associated resources
  - Can be used to build a transition project plan
  - And most importantly, **has measurable success criteria**

Putting the elements together…

- **Strategies**
- **Systems**
- **Subsystems**
- **Outcomes**
- **Influencers** (policies, organizations, people, technology, etc.)
- **Gaps**
- **Interventions**
- *How does it all fit together?*

Transformation Model Framework



The USCG Transition Process

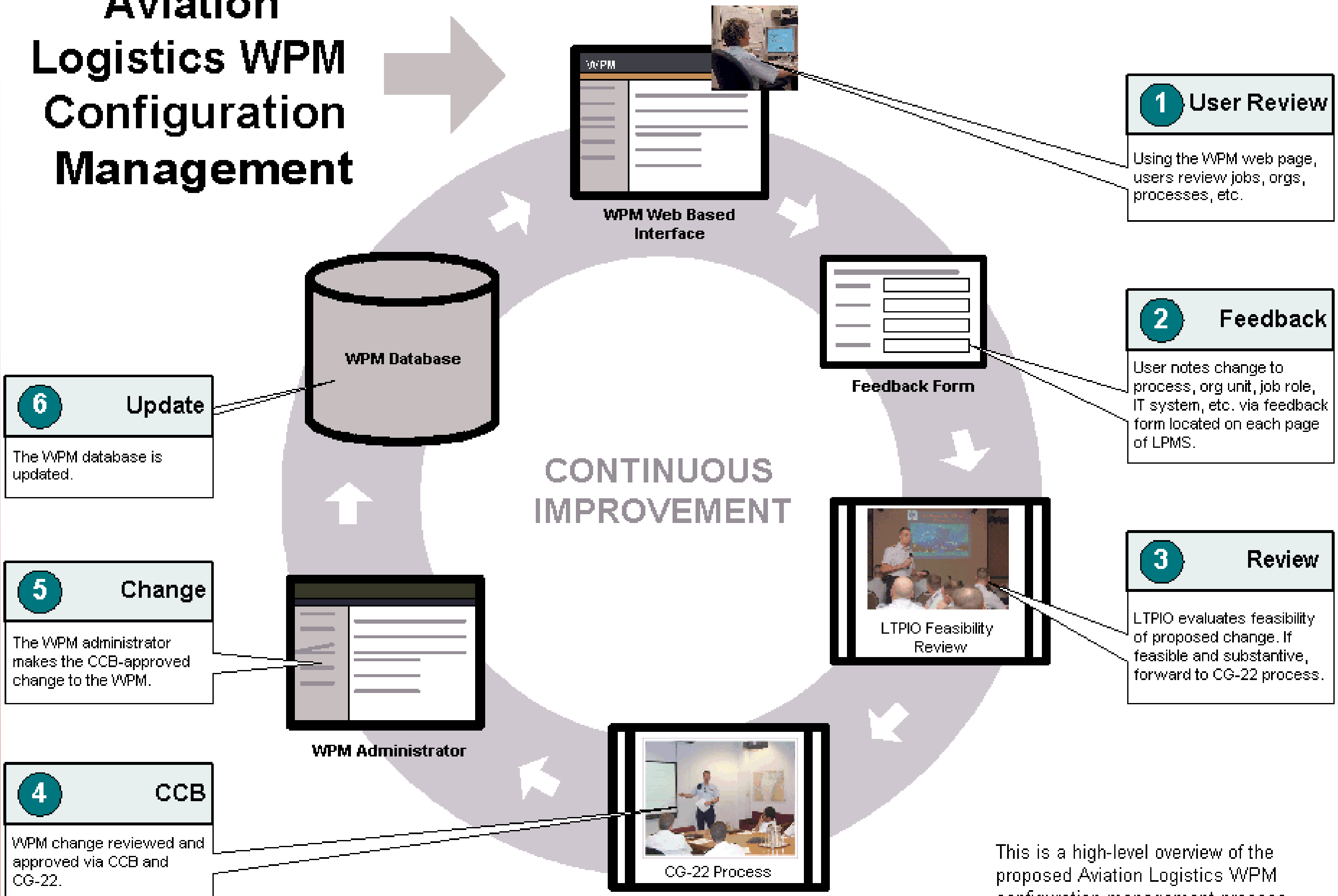
- LTPIO alignment conducted, **transformation objectives identified**
- Docs and resources reviewed
- SMEs identified
- **ILS systems outcome-based framework developed**
- Best practices identified by SMEs (42)
- Preliminary outcomes identified by SMEs (800)
- Org and strategic models defined
- **Key outcomes identified (250)**
- Framework relationships to key outcomes identified by SMEs (docs, job roles, policies, best practices, etc.)
- Skilled Performers (SPs) identified by USCG
- SP outcome review worksheets prepared
- SP outcomes reviews and validation conducted
- All data collected in Pathfinder Performance Modeler
- All data reviewed
- Analysis reports prepared
- PVs and PIs developed using facilitated meetings with LTPIO working groups
- Activity crosswalks prepared
- **Project plans and transition dashboards developed**
- **Transition training prepared and delivered**

Aviation Logistics Framework Scale

- 800 aviation logistics model outcomes were identified in all 10 ILS elements (and a cross-cutting set of subelements)
- 250 Key Outcomes (transformation drivers) identified
- Key Outcomes mapped to
  - 41 Systems
  - 698 Job roles, teams, or org units
  - 80 Documents (Policy/Directives/Statutes, etc)
  - 122 IT systems and features
  - 84 Strategic elements (goals and objectives)
  - Over 600 functional and business requirements
  - Over 7,000 performance factors and influencers
- Nearly 22,000 performance relationships

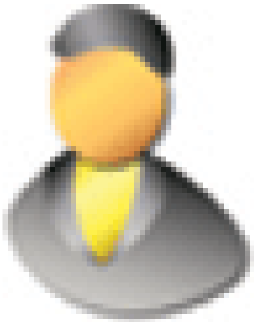
Model Configuration Management

Aviation Logistics WPM Configuration Management



This is a high-level overview of the proposed Aviation Logistics WPM configuration management process which can be used both to validate and enhance WPM content and also to manage its configuration over time.

People are Key



- **Changing the behavior of your people is the most difficult task of all…**

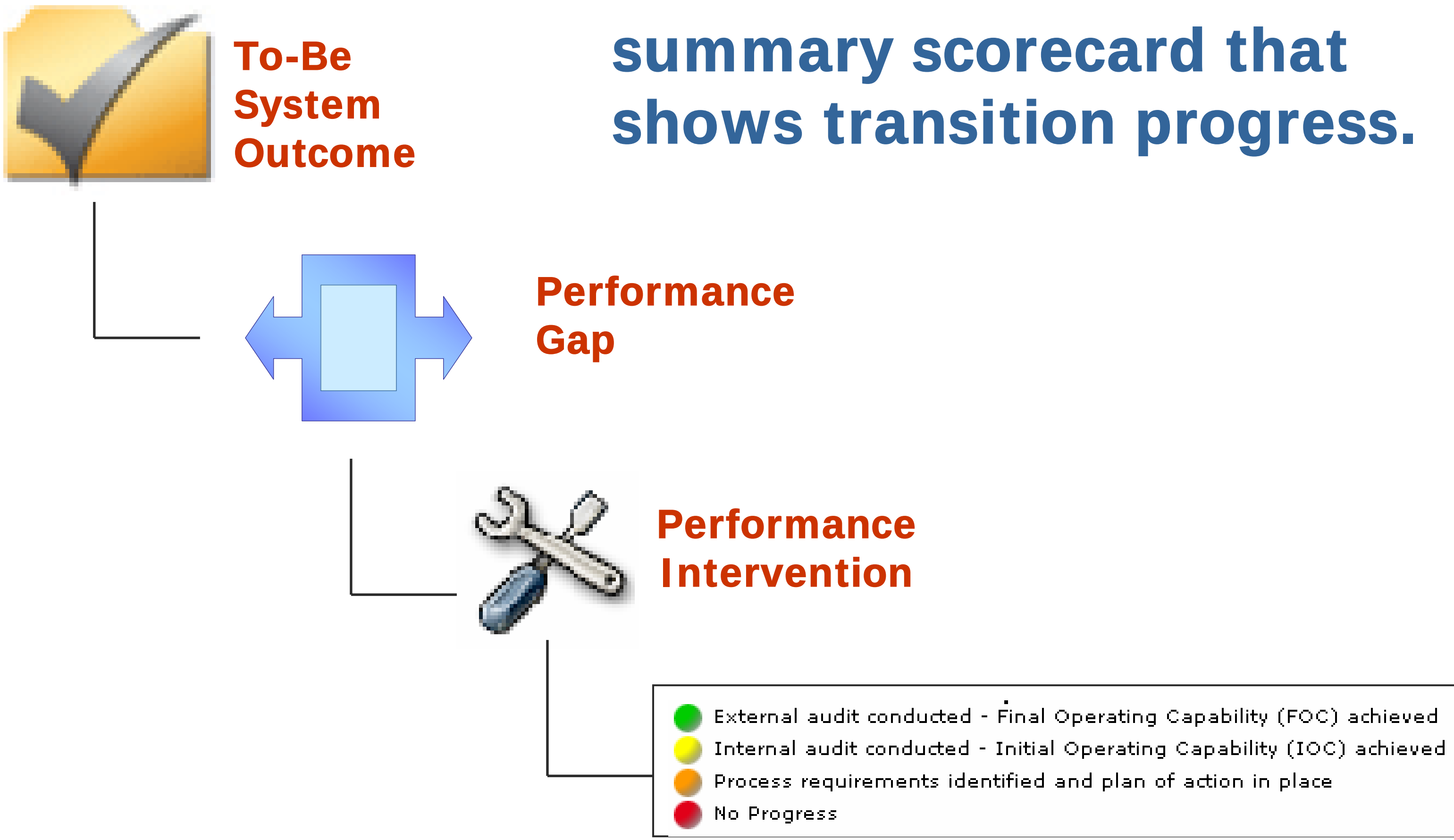
- Culture and politics are the most difficult roadblocks to logistics transformation
- You've got to convince people at all levels to change the way they operate.

Promoting cultural and political change

- Each outcome identifies human factors influencers (technological, environmental, social, and process)
- Relationships in model indicate cultural and political power bases
- Model enables stakeholders to “see” vision
- The **Transformation Dashboard** is key to producing measurable changes in organization, infrastructure, processes, systems, and behavior.
- Manages and measures progress in **making the changes required to achieve “to-be” outcomes**

Transition Success Criteria

Each level includes a summary scorecard that shows transition progress.



Example Success Criteria

- **Outcome: Authorized Chemical List**
  - **Intervention: Chemical Locker Storage Established**
  - **Criteria:**
    - **Red:** No Progress
    - **Orange**: Location for chemical storage locker identified.
    - **Yellow**: Authorized Chemical List established and utilization instruction developed and signed by Sector Engineering Officer.
    - **Green:** Personnel trained in proper storage procedures and usage of the Chemical locker IAW Hazmat plan.
    - ***Owner, schedule criteria, compliance inspection process, etc. defined for intervention in model***

Sample USCG Scorecard

Logistics Transition Executive Dashboard - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Overall Transition Progress Score > Asset Transition Lifecycle Scorecard > 25, RB-S ILS Scorecard >

Maintenance Scorecard

This is a score that measures the aggregate scores of all standard boat transition activities within this ILS element. When this score turns green, it indicates that all the subordinate scores are also green and that this boat class has met all transition objectives for this ILS element.

Created: tanisha 8/21/07 4:58 PM
Edited: pcumby 9/21/07 4:26 PM

Status: Not Reviewed
Tasks: 0

This scorecard is a rollup summary of the following scores:

	Orange Criteria	Yellow Criteria	Green Criteria
2813 Asset enrolled in ACMS	Review Outcome processes in WPM, identify requirements for achieving the outcome, and put plan in place.	Internal leadership verify enrollment form is filled out for installed and spare components. Data entry and initial asset enrollment complete.	External audit reviews process and verifies that asset is enrolled in ACMS.
2833 Accurate, standard MPC graphics	Review Outcome processes in WPM, identify requirements for achieving the outcome, and put plan in place.	Graphic submitted to APO Graphics Department for Tech Illustrator vectorization. Completed graphic hyperlinked to MPC. Internal audit of MPC completed.	External audit reviews MPC graphic related processes and deems satisfactory.
4255 Mandatory Special Requirements (MSR) List	Review Outcome processes in WPM, identify requirements for achieving the outcome, and put	Internal leadership verifies that ACMS task codes are assigned to MSR items. Completed MSR List enrolled in ACMS.	External audit reviews MSR list and deems satisfactory.

Summary

- Performance Model Framework identifies all elements of logistics system performance
- All relationships between systems elements are defined
- Performance outcomes are central to model
- Each outcome has transition plan that identifies gaps and interventions
- Each intervention has measurable success criteria
- Success criteria form the basis for the Transition Dashboard
- Transition Dashboard drives systems, organizational, technological, and behavioral change

Demos and Questions

- USCG Logistics Performance Management System (LPMS)
- Logistics Transition Dashboard
- Transformation support materials

Experiences in Applying SysML to Develop Interoperable Torpedo Modeling and Simulation Components

Presented to:
NDIA
10th Annual Systems Engineering Conference
San Diego, CA

Presented by:
Thomas Haley
Naval Undersea Warfare Center
Division Newport
Newport, RI

24 October 2007

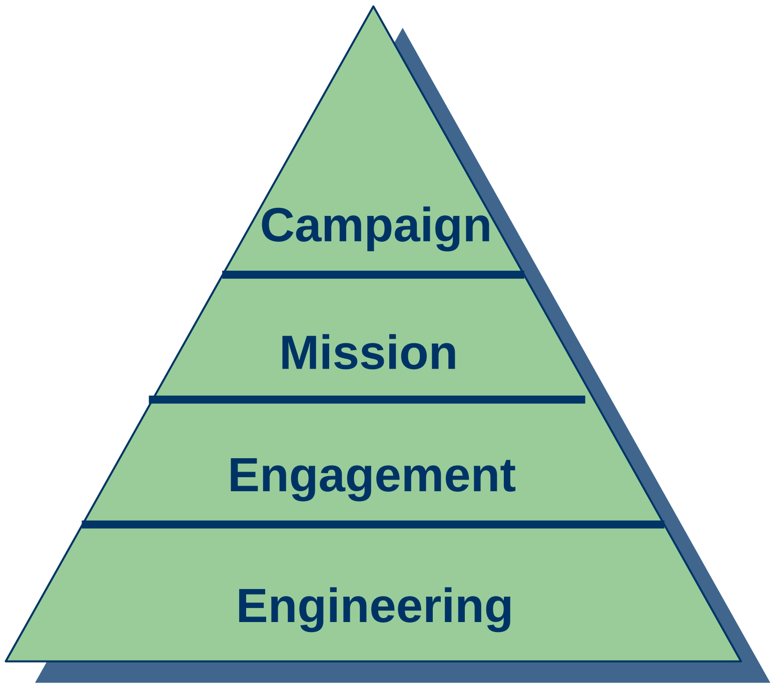
Outline

- SysML Case Study Motivation
- TEAMS Project Background
- SysML Proof of Concept
- Lessons Learned
- TEAMS Perspective: SysML Pros and Cons
- Acknowledgements

Motivation: Feasibility of Open Standards

- **Funded by Office of Secretary of Defense, Systems and Software Engineering**
- **Determine if open standards can be used to describe:**
  - **System of systems (SoS) architectures based on computer models**
  - **System components as elements of composable distributed simulations**
- **Determine whether SysML models can be used in conjunction with performance simulation models**

Background: TEAMS Simulation Scope



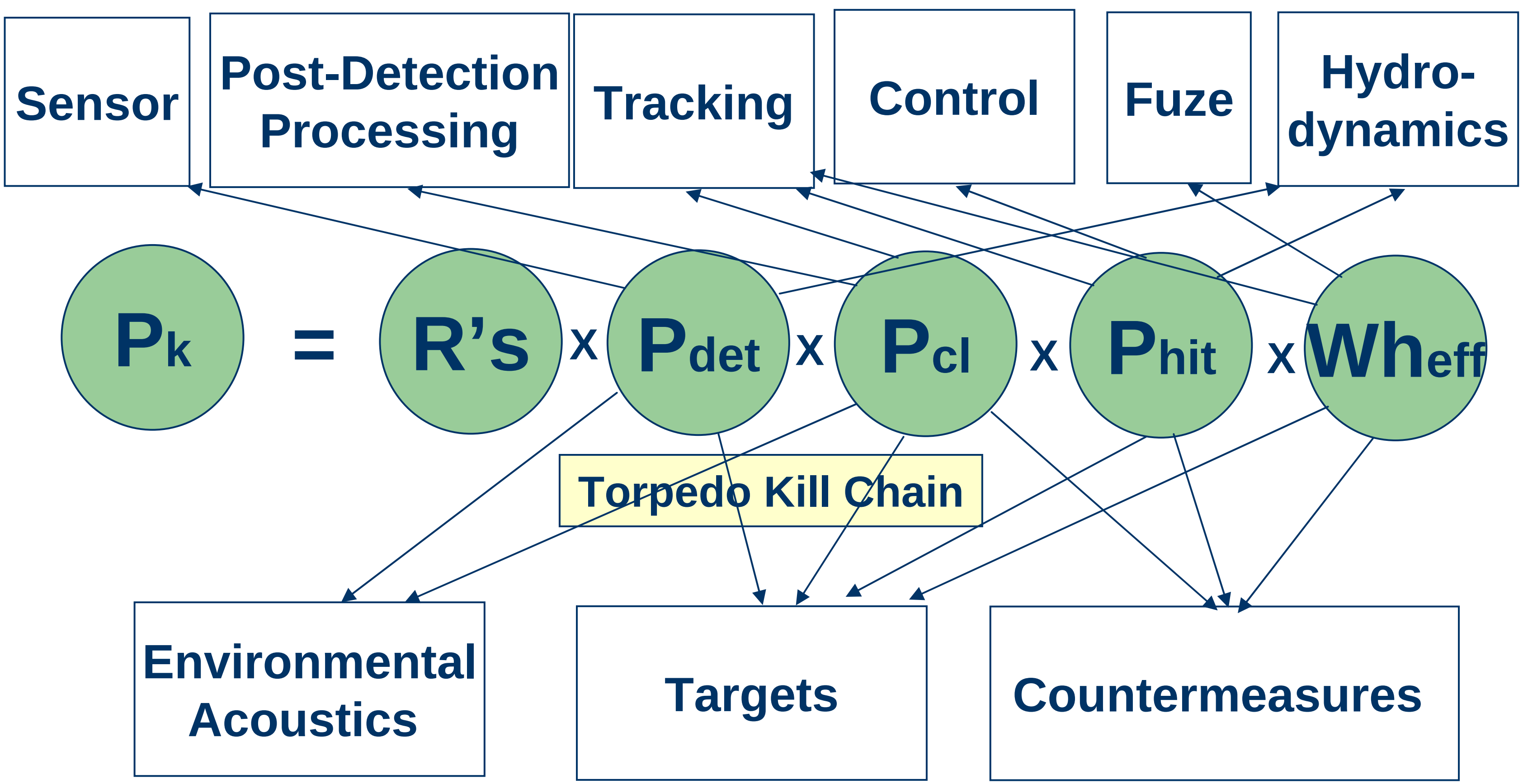
TEAMS Emphasis: “Launch-to-Hit” Analysis

Military M&S Resolution Levels

TEAMS: Torpedo Enterprise Advanced Modeling & Simulation

Background: High-Level M&S Requirements

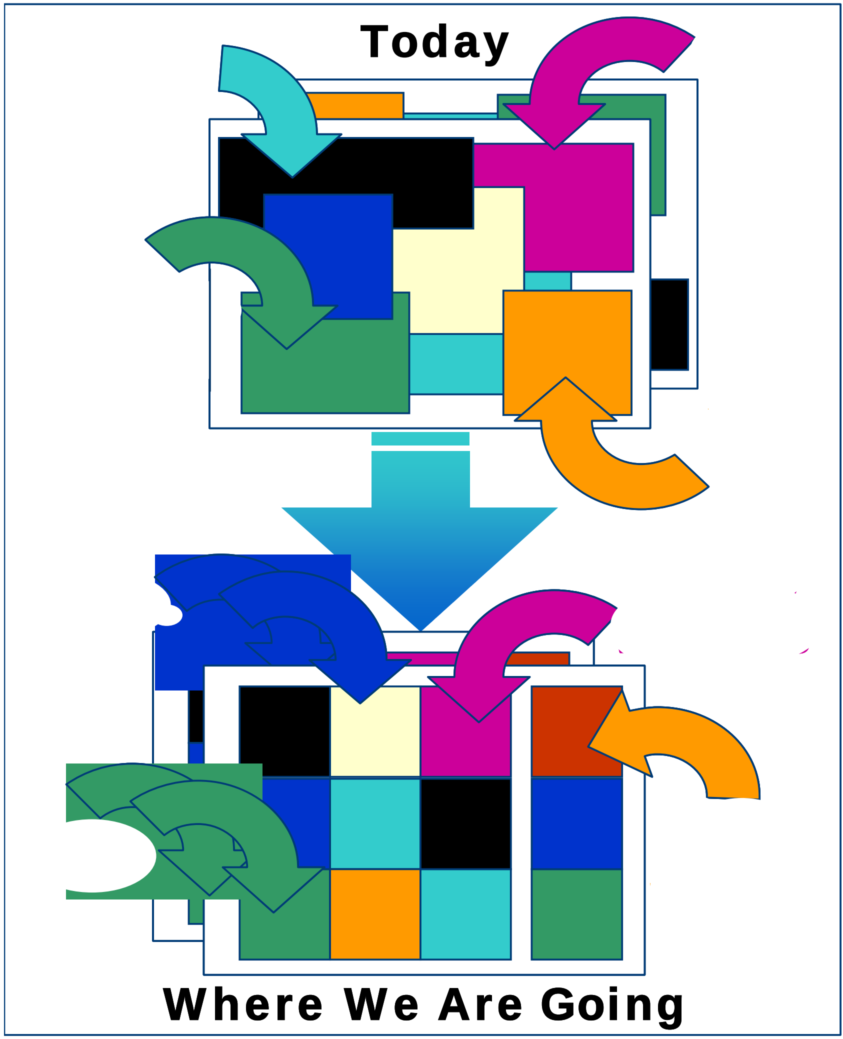
Torpedo M&S Components



Other "Stimulus" M&S Components

TEAMS Background

- **Problem: Modeling & Simulation Business “Model” Obsolete**
  - Monolithic
  - Stove pipes
  - Single developers
  - No communication
- **Solution: Foster Collaborative M&S Development Environment**
  - Standardize M&S architecture framework and component models
  - Reduce the technology development timeline
  - Increase model content, implementation efficiency and reuse
  - Reduce cost



Overall TEAMS Goals

- Modeling and Simulation Community Collaboration
- Standardized architecture framework
  - Conceptual reference model
  - Model-based requirements specifications
- Standardized reference model interfaces
  - Interchangeable & composible components
  - Extendable to other applications (e.g., XML schema)
  - Semantically described (e.g., OWL ontology)
- Document standards and requirements
- Cost effective process to achieve interoperability and composability
- Business model for future cross-organization M&S funded efforts

TEAMS Core Requirements

1. Standard Interfaces
2. Platform Independence
3. Open Standards
4. Model Realizable Systems
5. Extensible Interfaces
6. Evolving Standards
7. Loosely Coupled Interfaces
8. Tiers of Interfaces
9. Support Different Levels of Detail
10. Standard Implementation Strategies

Organizations Looking to TEAMS

International organization, developers of TOGAF architectural framework

- Wants TEAMS as test case for TOGAF 8.1.1 and 9.0

- Interest in using TEAMS to test synergy between DoDAF and TOGAF frameworks

- Wants TEAMS for its process to incorporate Ontologies (relationships of components)

International organization, developers of several business communications standards

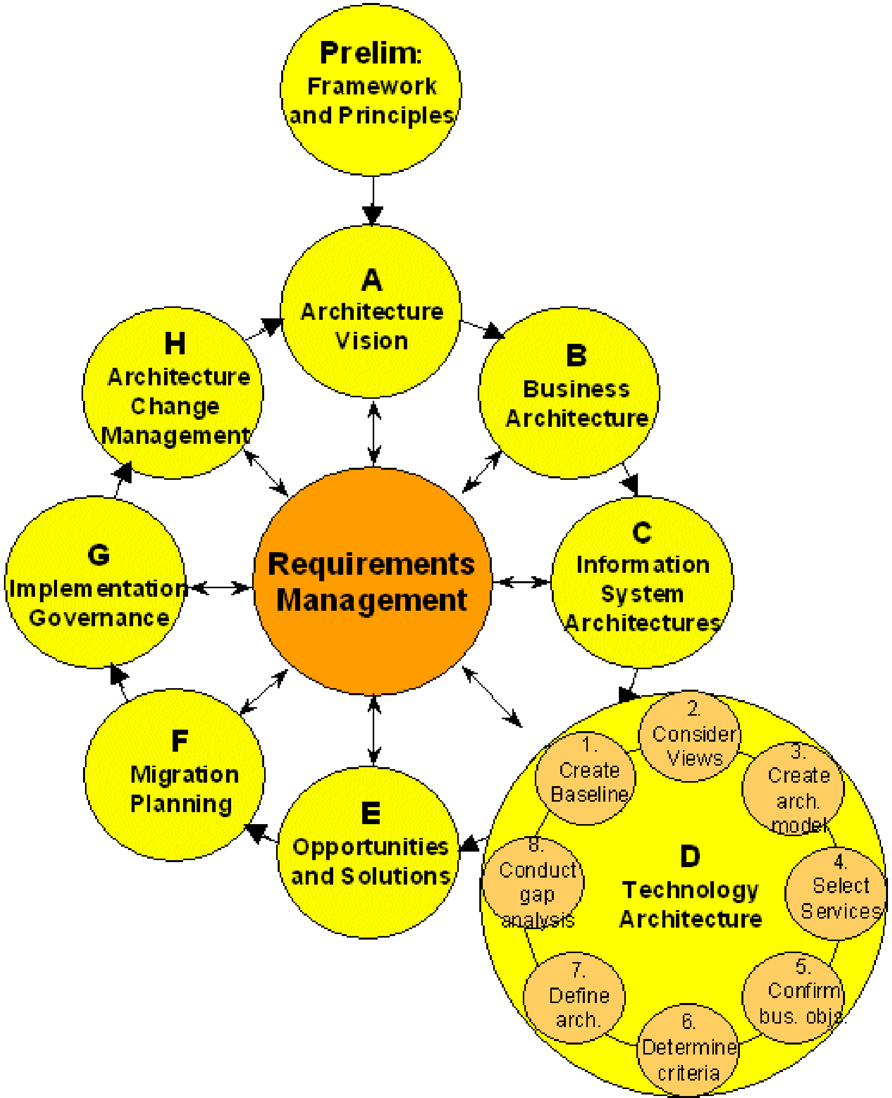
- Used TEAMS as test case for their TOGAF/ Model Driven Architecture (MDA) under the TOGAF/MDA Synergy Project

The Open Systems Joint Task Force of the Office of Secretary of Defense (OSD)

- Wants to convert TEAMS UML artifacts to the newly approved SysML standard to demonstrate utility of the new standard

TEAMS is quickly yielding *highly visible* and *transitionable* results.

High-Level Process: TOGAF ADM



The Open Group: IT Consortium Offers Consortia Services

TOGAF: The Open Group Architecture Framework

ADM: Architecture Development Method

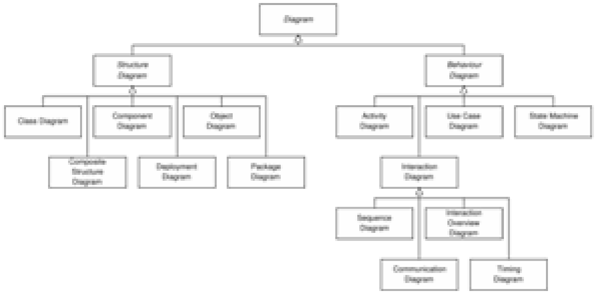
"OMG™ is [a] … not-for-profit computer industry consortium … developing enterprise integration standards for a wide range of technologies [… / …] industries … enabl[ing] powerful visual design, execution and maintenance of software and other processes…"

- CORBA – Common Object Request Broker
- UML – Unified Modeling Language
- SysML – Systems Engineering Modeling Language
- Numerous others in diverse industries (e.g., business)
- Developer of Model Driven Architecture (MDA) method

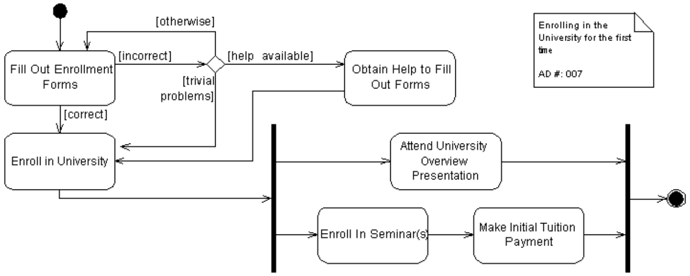
OMG has a model-based emphasis in developing standards

UML

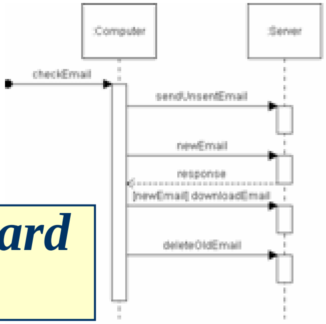
UML Consists of 13 Diagrams



Structure: E.g., Class Diagram



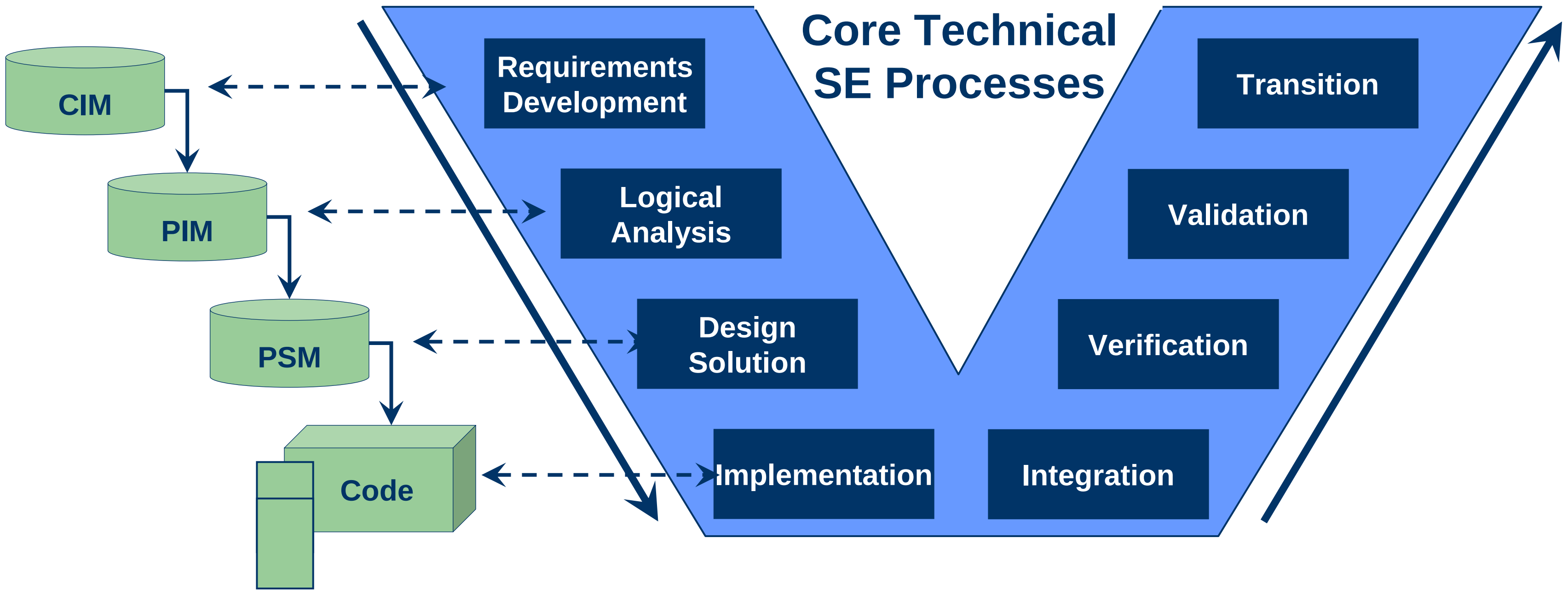
Behavior: E.g., Activity Diagram



Interaction: E.g., Sequence Diagram

OMG models are MOF-Based - Meta-Object Facility Standard
Think "TurboTax"

Using MDA in SE Context

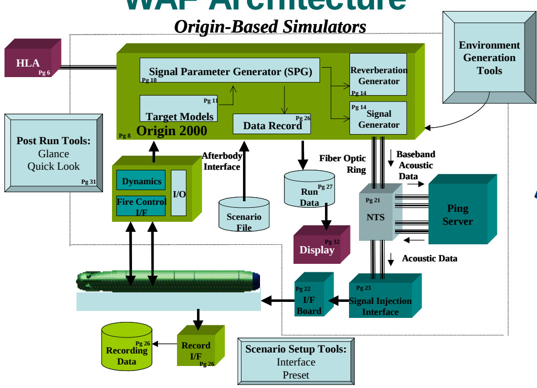


The implementation (code) for technology selected by the developer

Baseline Technology Architecture

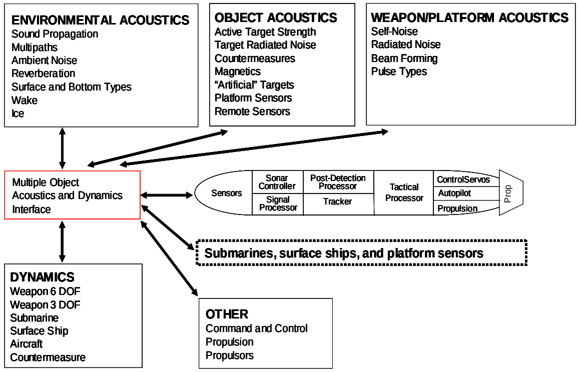
Weapons Analysis Facility (WAF)

WAF Architecture



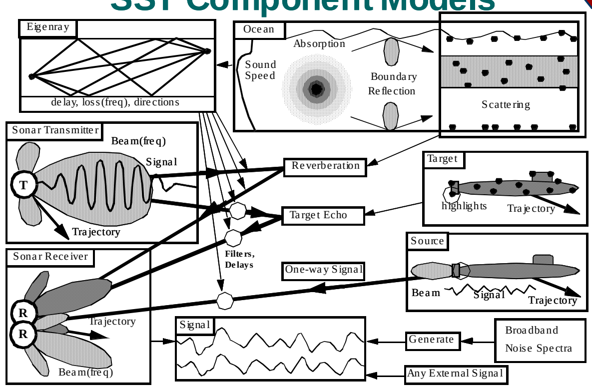
Technology Requirements Model (TRM)

TRM's CARLEE

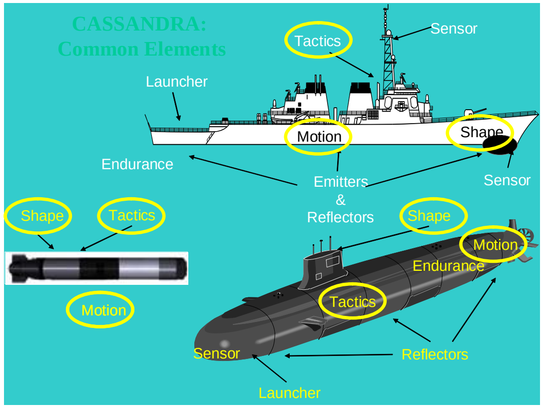


Conceptual Reference Model

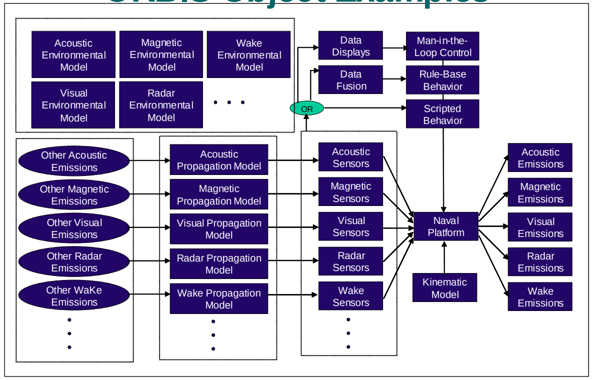
SST Component Models



CASSANDRA Common Elements

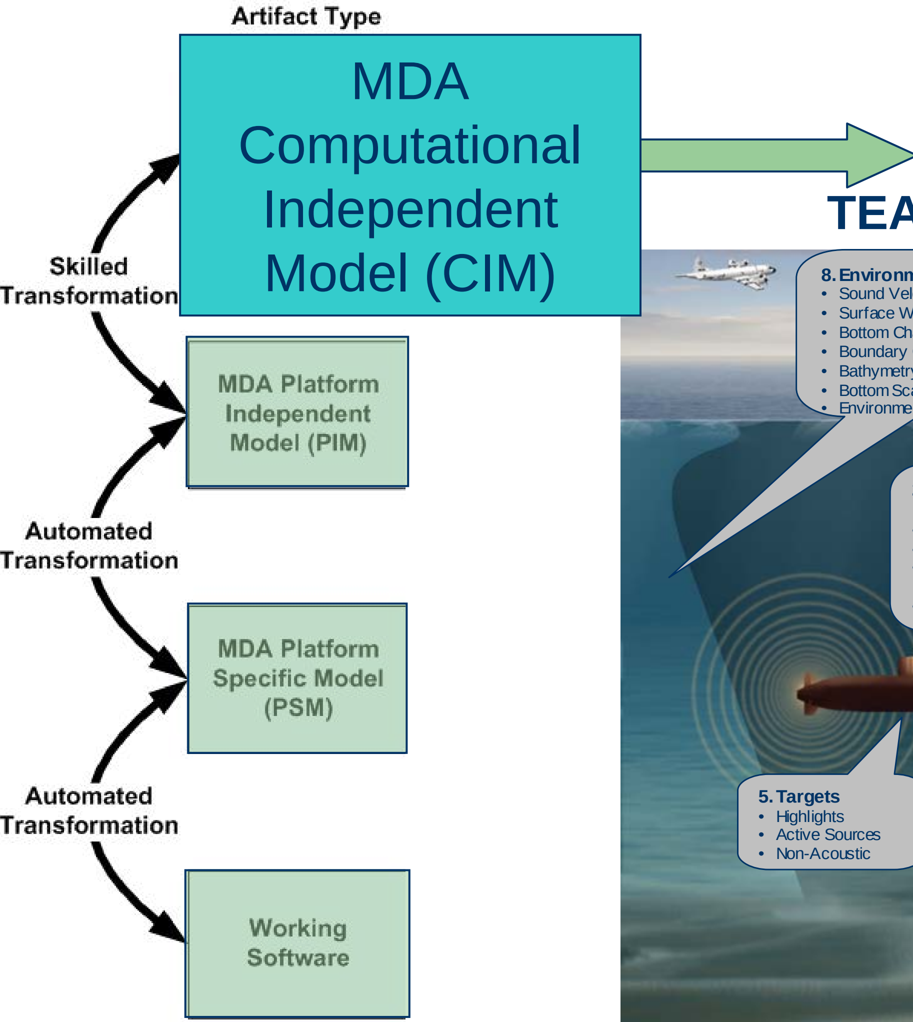


ORBIS Object Examples

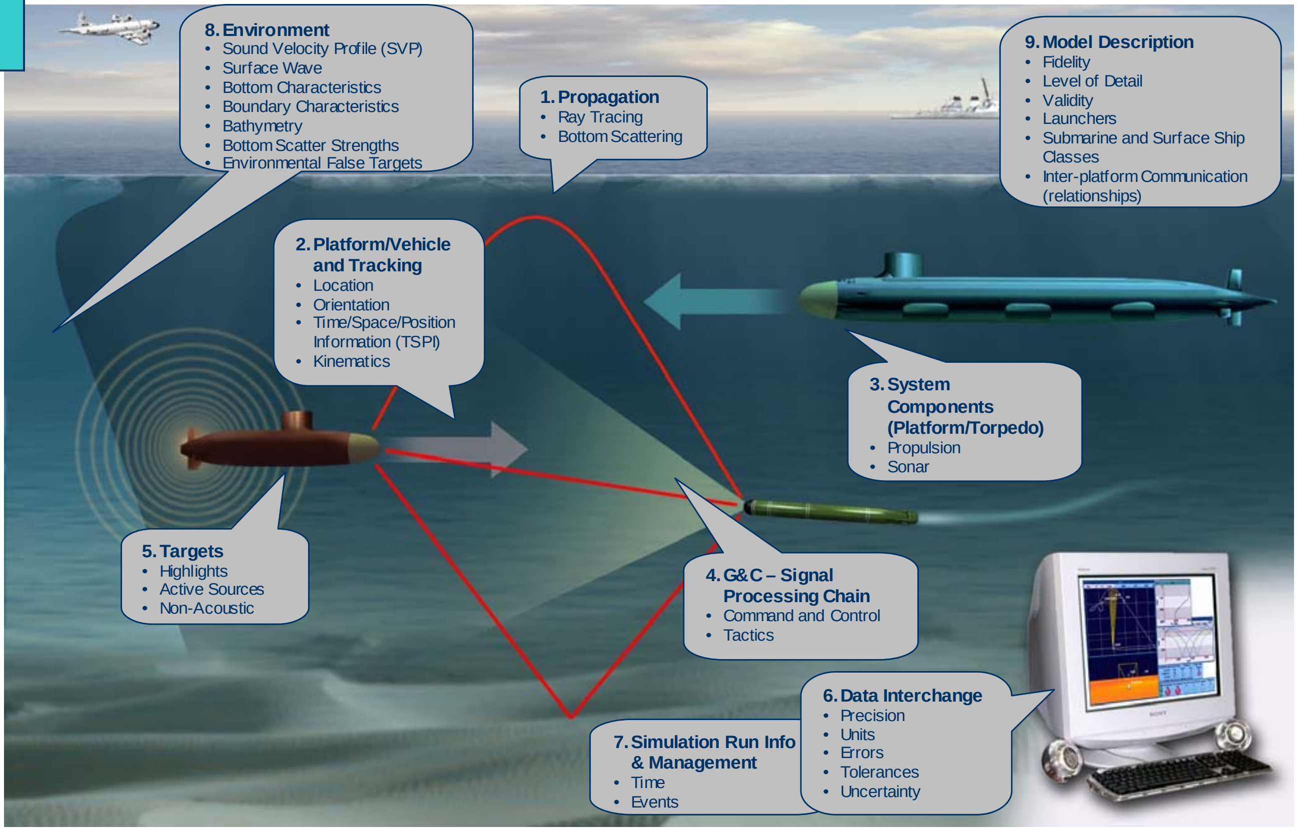


Sonar System Toolset (SST)

The Method:
Model Driven Architecture (MDA)



TEAMS Conceptual Reference Model



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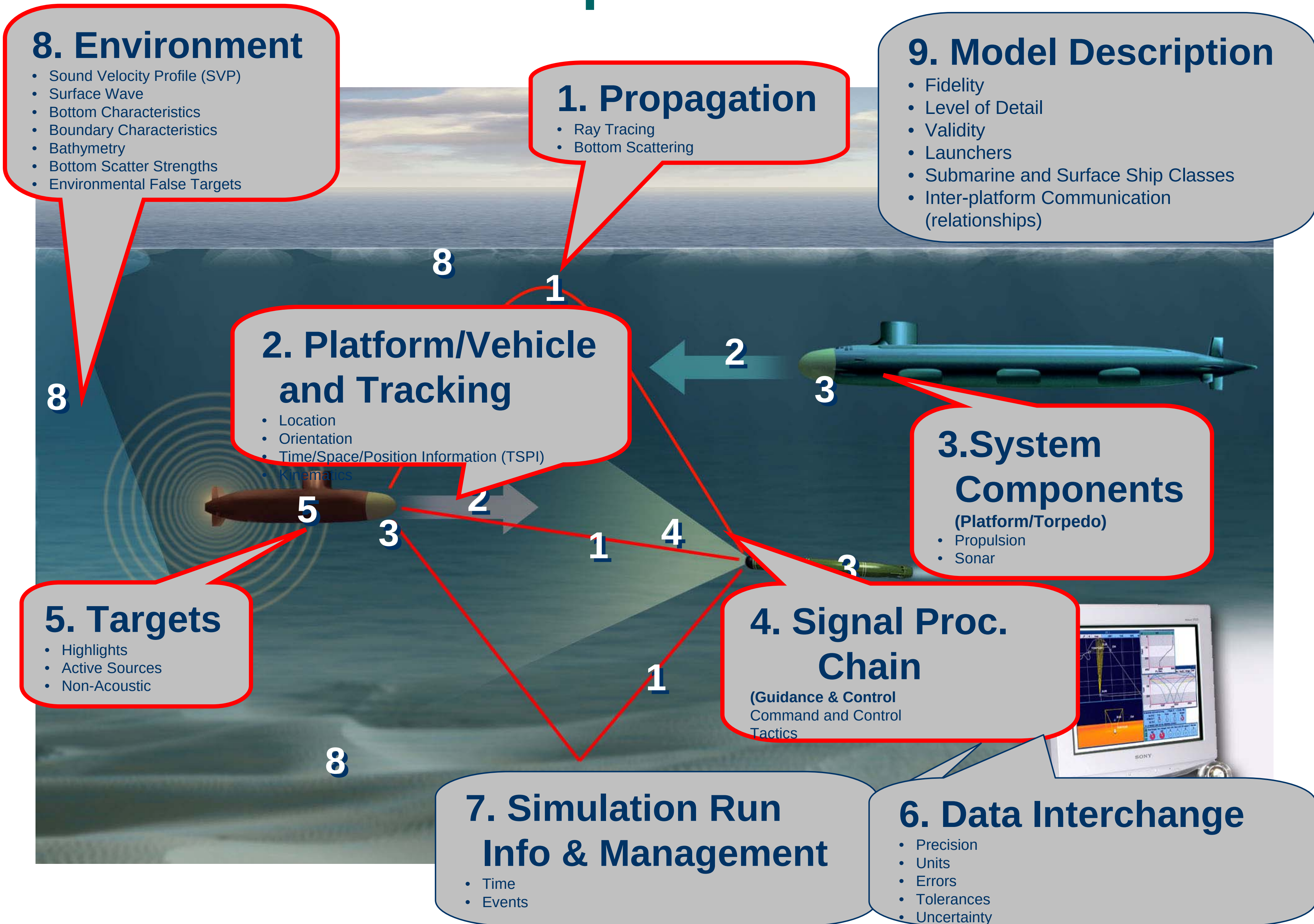
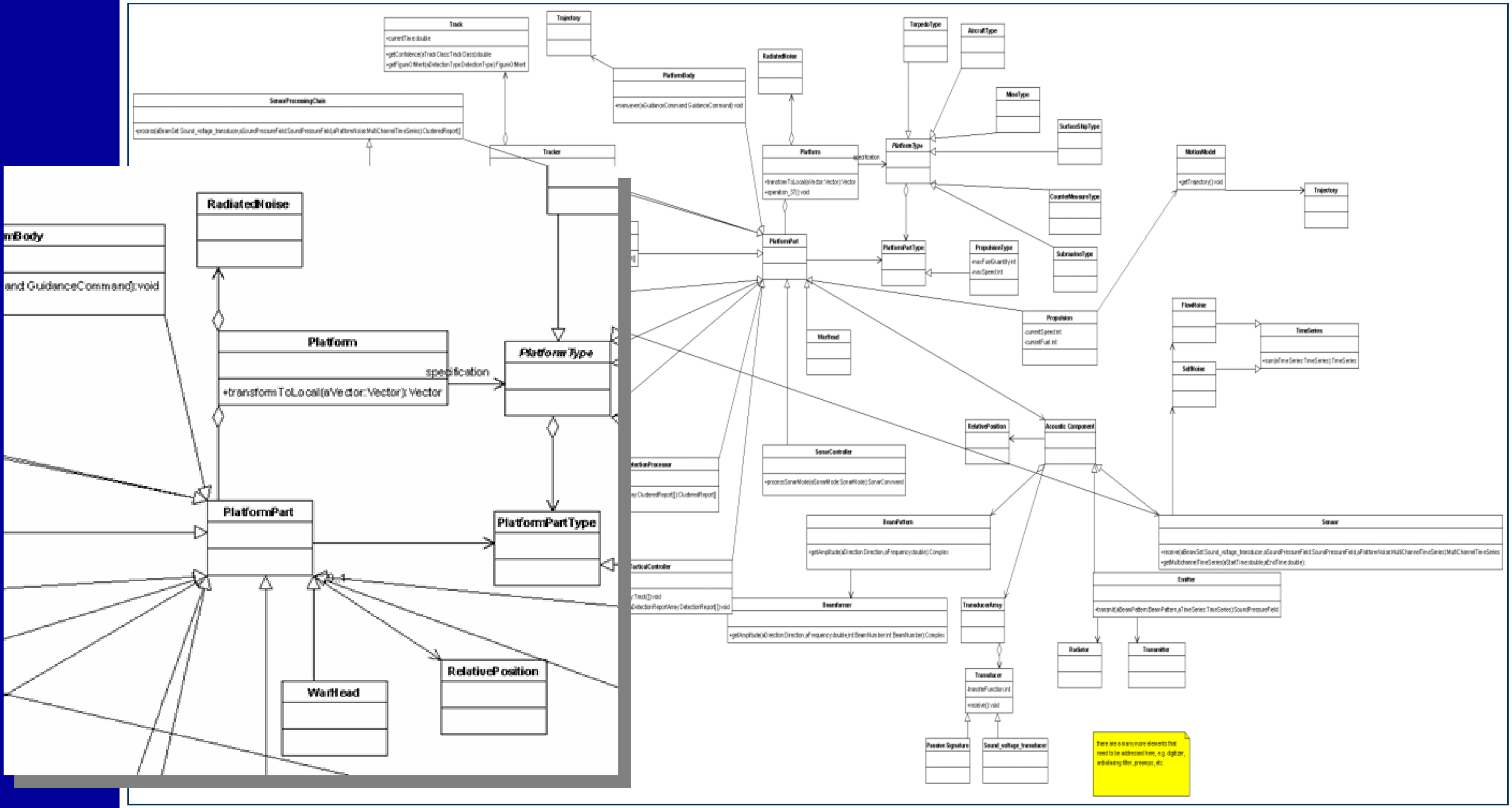
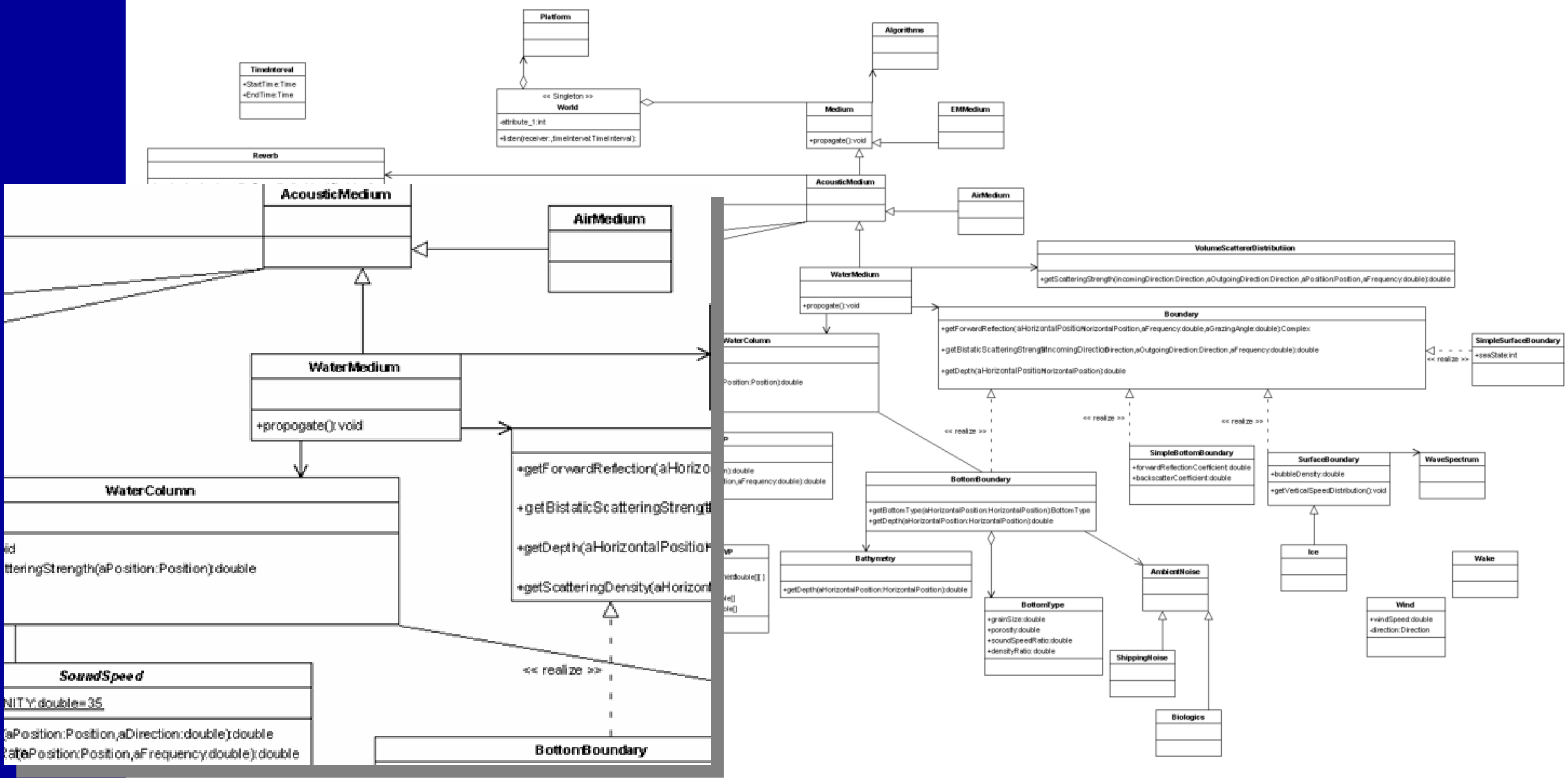


Platform Conceptual Level Diagram



Environment Conceptual Level Diagram



The Method:
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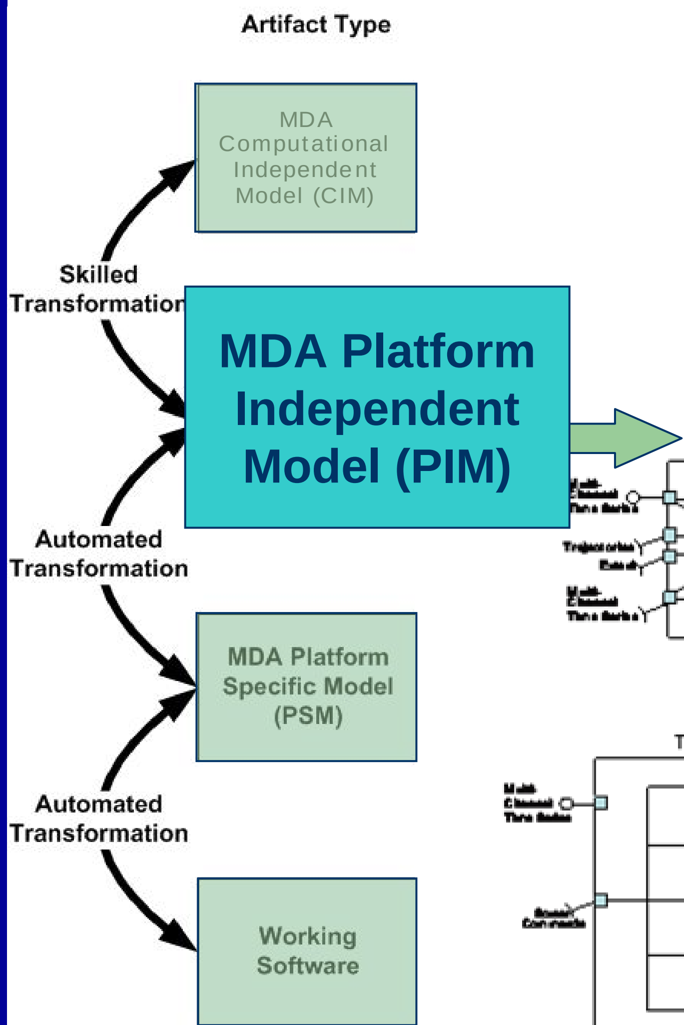
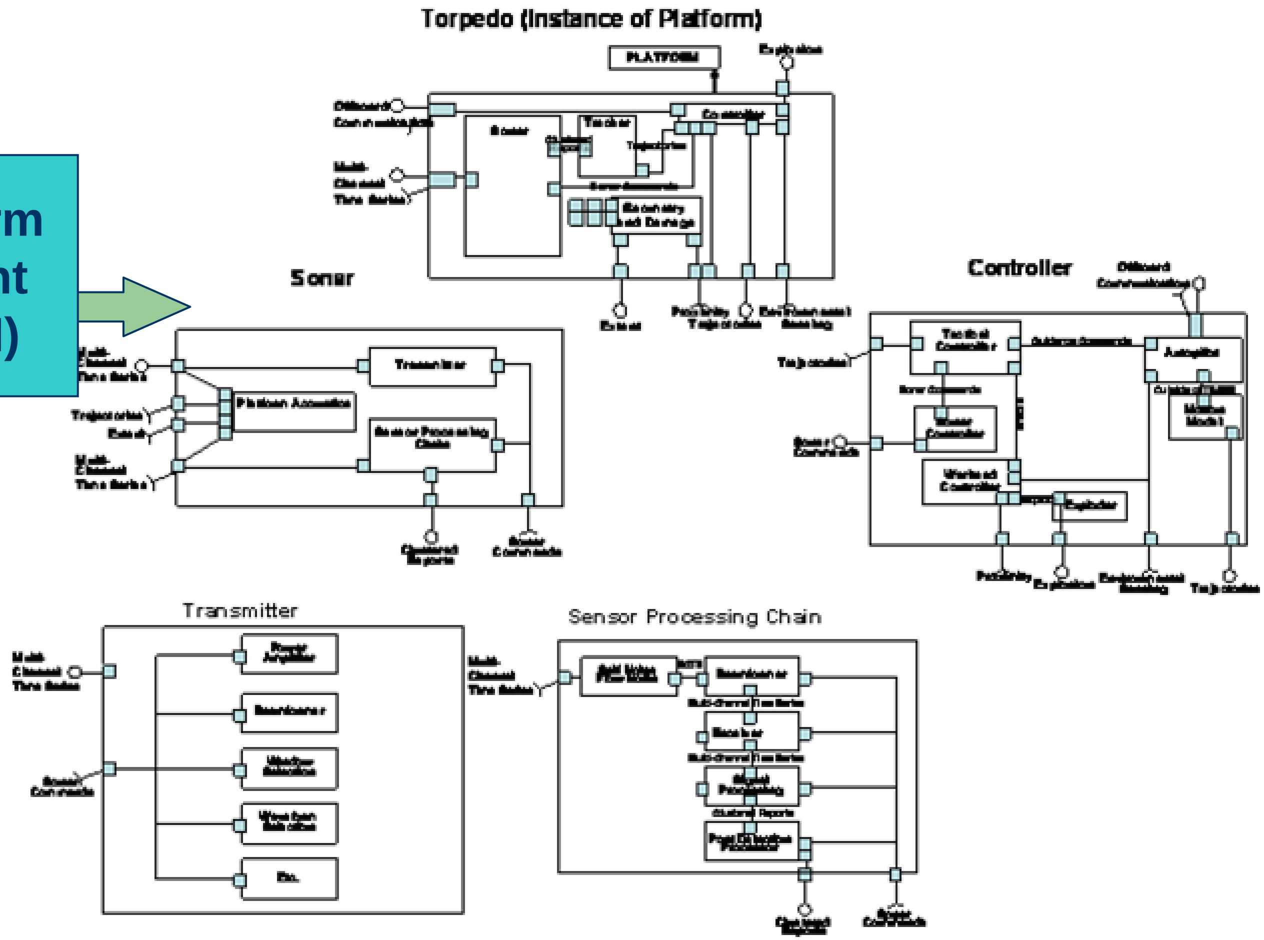
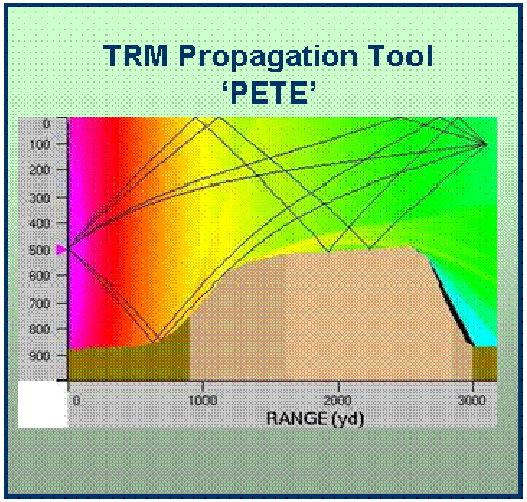


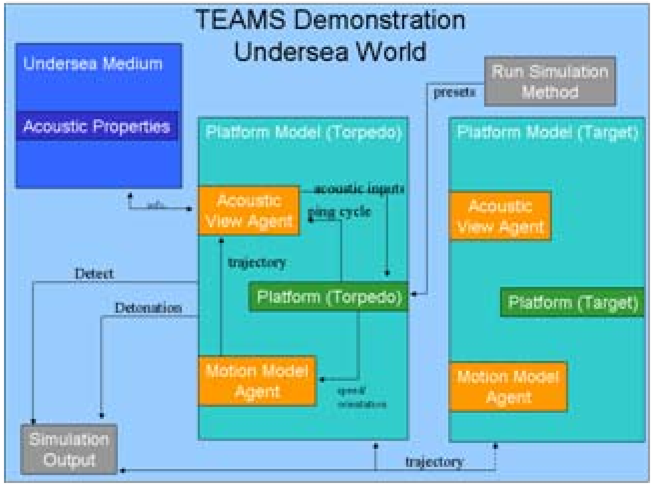
TEAMS UML Component Diagrams
(Now Represented in SysML)



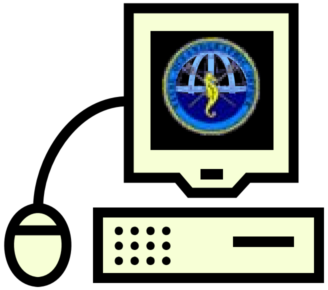
TEAMS PSM: Implementation

Reference Implementations





In-situ Environmental Data
via Web Services



NAVOCEANO
SIPRNET Web Site

Jackson Bottom Model via CORBA

Applied Physics Lab
University of Washington

Closed-Loop SimuLink™ Torpedo,
Environment & Target

PMS 404
UNDERSEA WEAPONS PROGRAM OFFICE

TEAMS SysML Proof of Concept

- Port existing UML to SysML
  - Torpedo system components
  - Simulation environment
- Extend TEAMS SysML to include:
  - Requirements traceability
  - Parametrics and constraints
- Share experiences and lessons learned using SysML for architecture and component modeling

UML to SysML Approach

- **Convert UML Class Diagrams to SysML Block Definition Diagrams (BDDs)**
- **Convert UML Component Diagrams to SysML Internal Block Diagrams (IBDs)**
- **Represent Behavior Relationships Between Blocks as Activity Diagrams *(new!)***
- **Capture Requirements Traceability *(new!)***
- **Capture Parametric Relationships and Constraints *(new!)***

TEAMS Perspective: SysML Pros and Cons

Pros

- Requirements
  - Explicitly lay out requirements and consequences
- Views and Viewpoints
  - Can separate requirements and model views based on stakeholders concerns
- Structure
  - Ability for model structure to verify requirements
    - Can search for requirements that aren't verified
    - Can search for model components that aren't justified
  - Separation of structure from behavior
    - SysML BDDs vs. IBDs and Activities allow for clear separation
    - UML allows this, but easier to implement in SysML
- Behavior
  - Dashed line for activity flow is more aesthetically pleasing
    - vs. UML solid line

Cons

- Allocating CIM to PIM
  - Difficulty with abstract activities
    - Exit path dependent on logic within an activity is not accessible and can't be modeled
    - Not represented well in either UML or SysML – tactical controller example
- Implementing PIM
  - Not "direct" for some SysML features
    - Flow ports, continuous activities, parametric constraints involve more components than just themselves
    - Flows in "real systems" easier to represent
    - Flows in software modeling are open to interpretation
  - Requires additional documentation of model to bridge between SysML feature and executable code

TEAMS Perspective: SysML Pros

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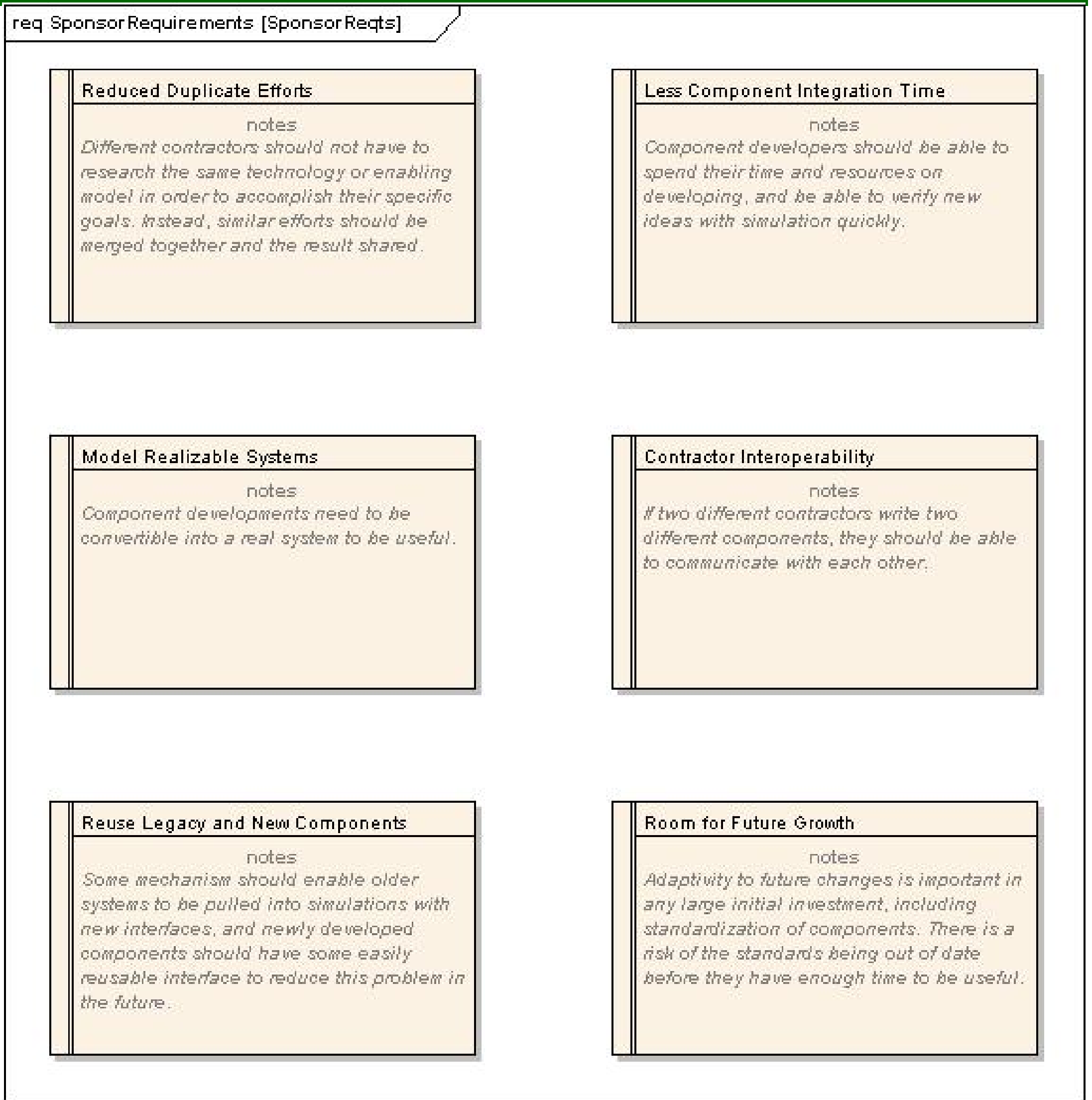
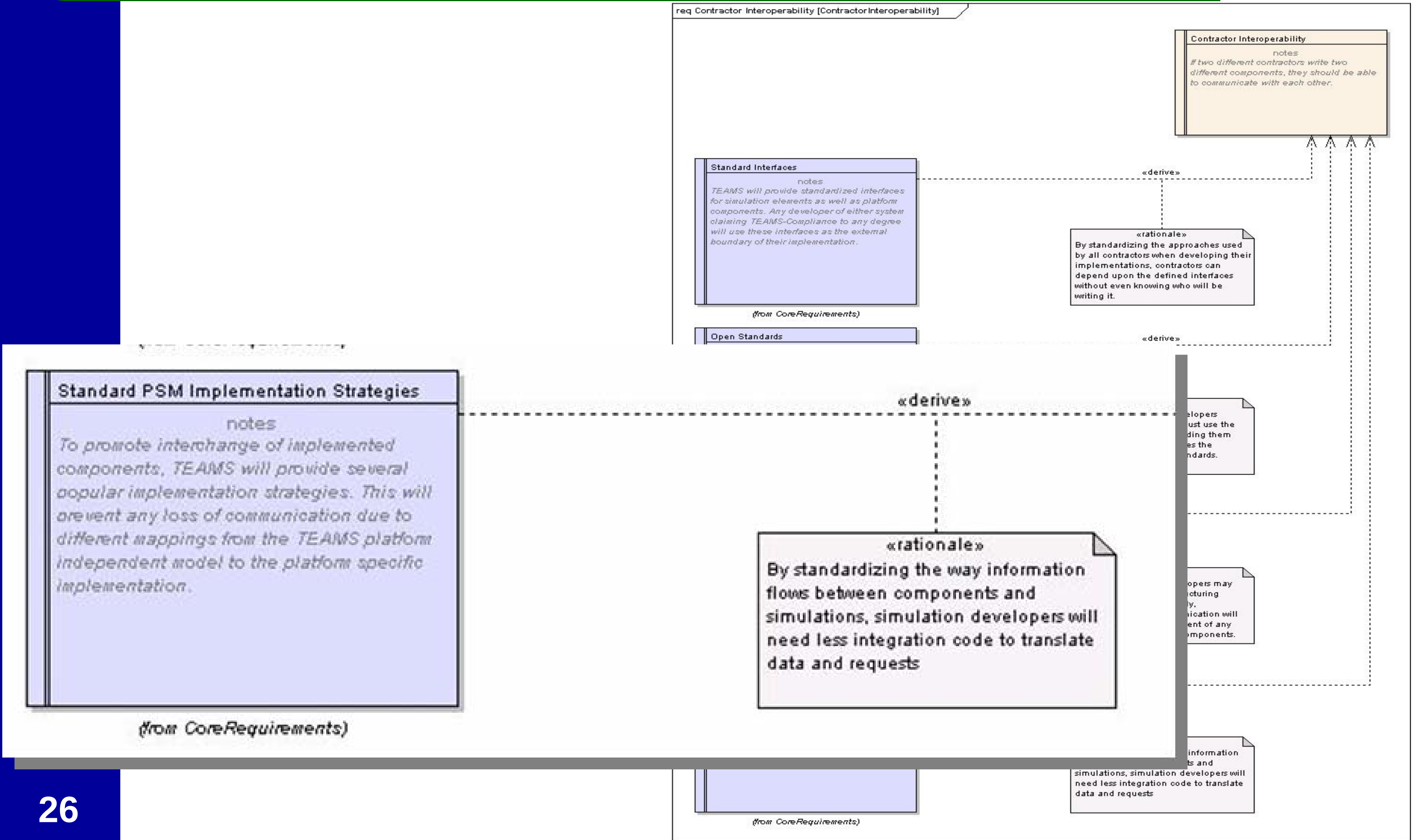
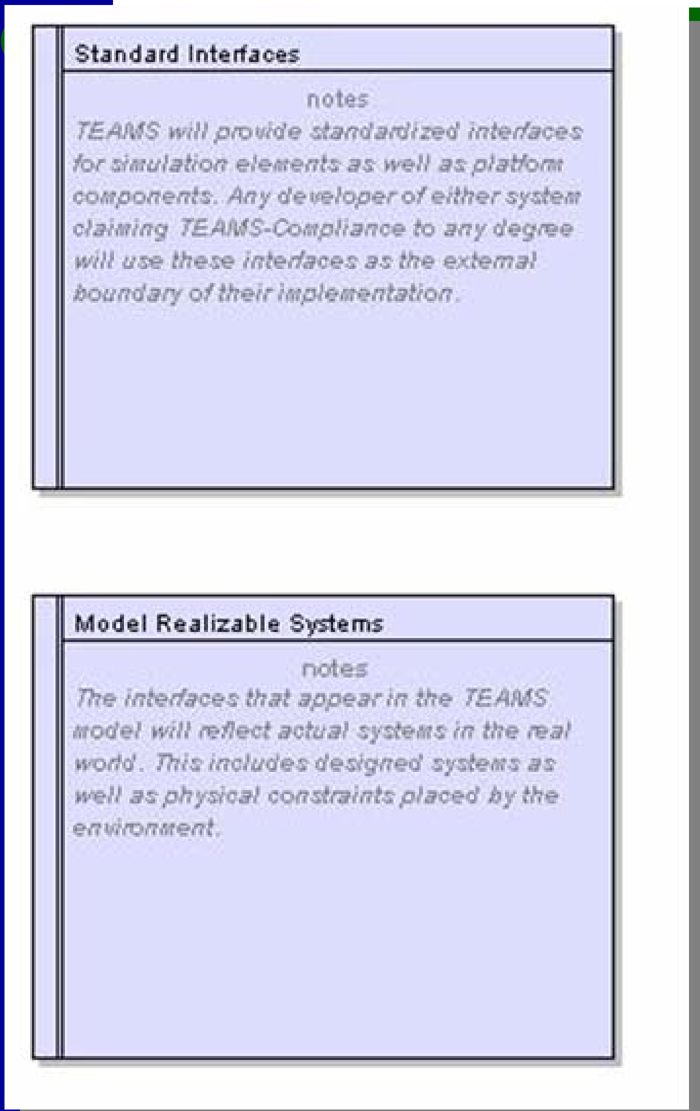
Sponsor Requirements



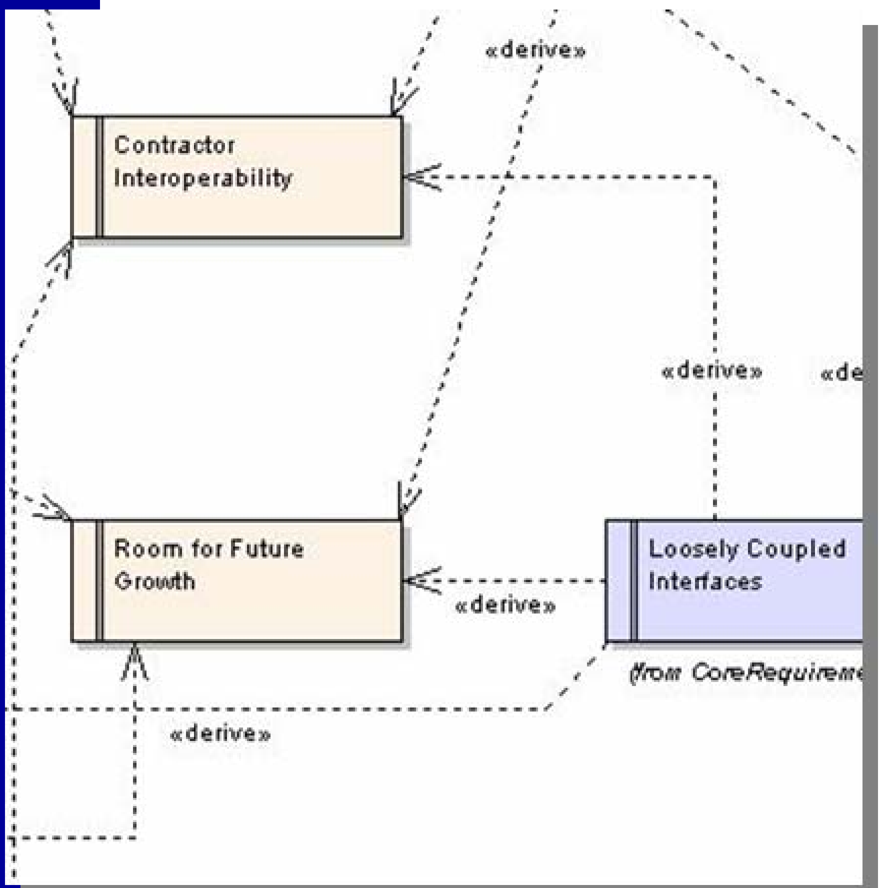
Rationale for Deriving TEAMS Core Values from Sponsor Requirement(s)

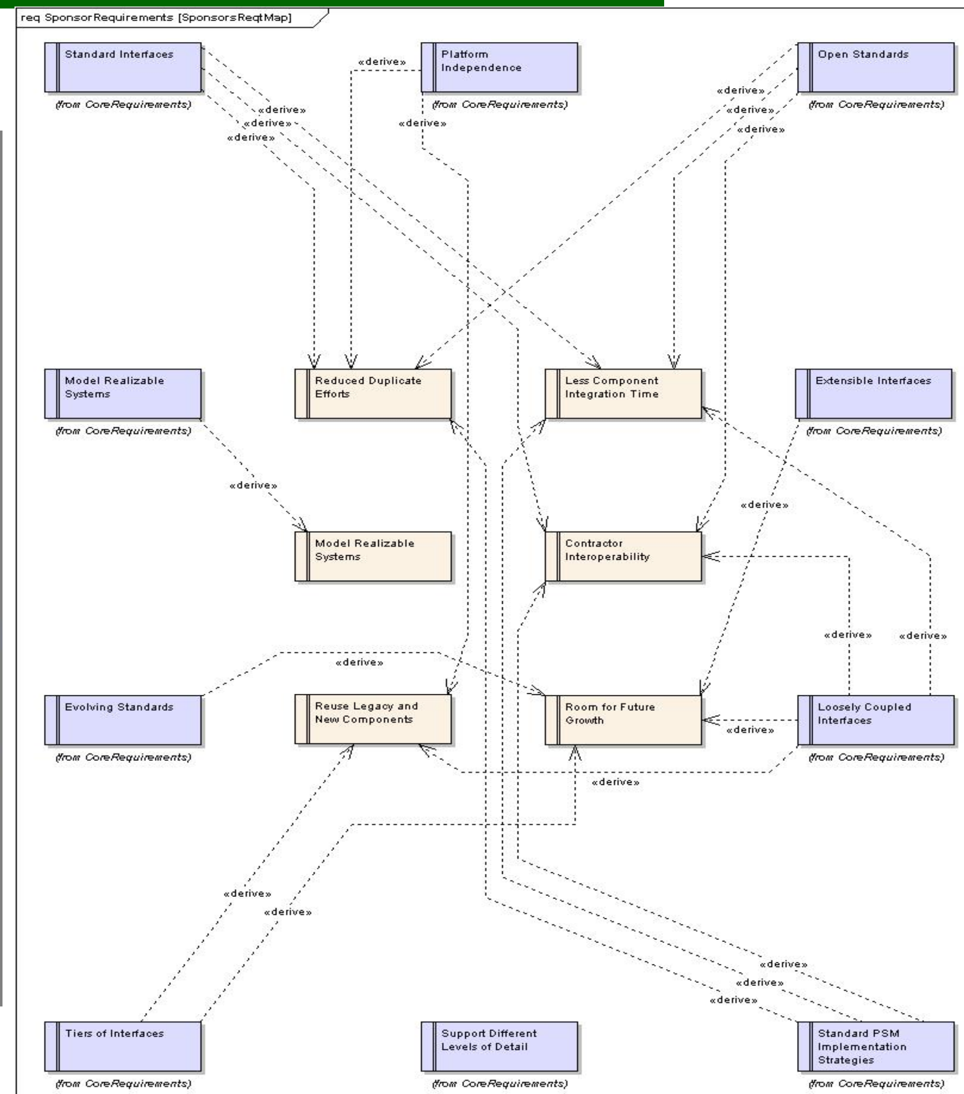


Requirements Traceability: TEAMS Core Values



Sponsor Requirements Mapped to TEAMS Core Values





TEAMS Perspective: SysML Pros

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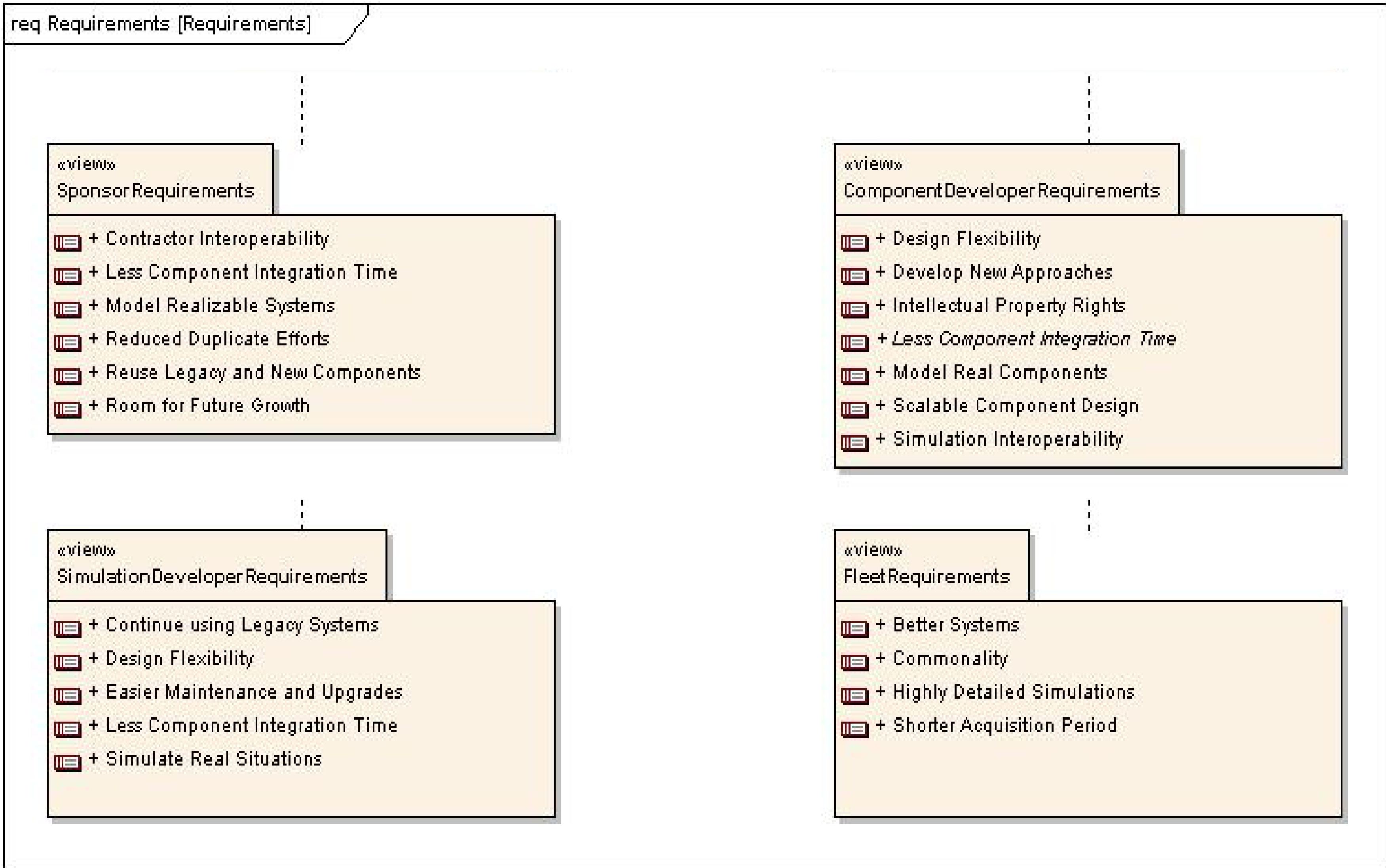
TEAMS
Stakeholder Requirements

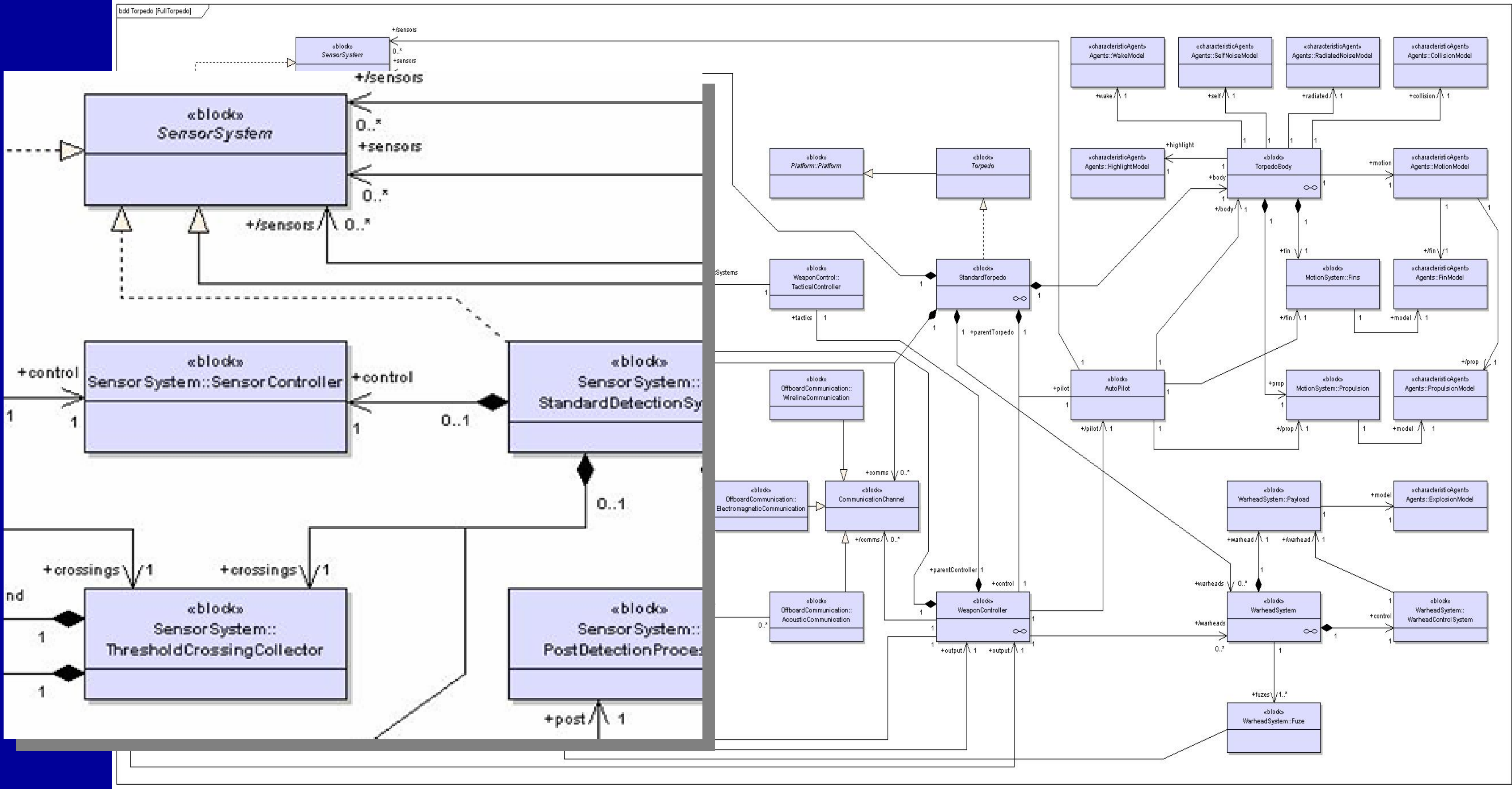


TEAMS Perspective: SysML Pros

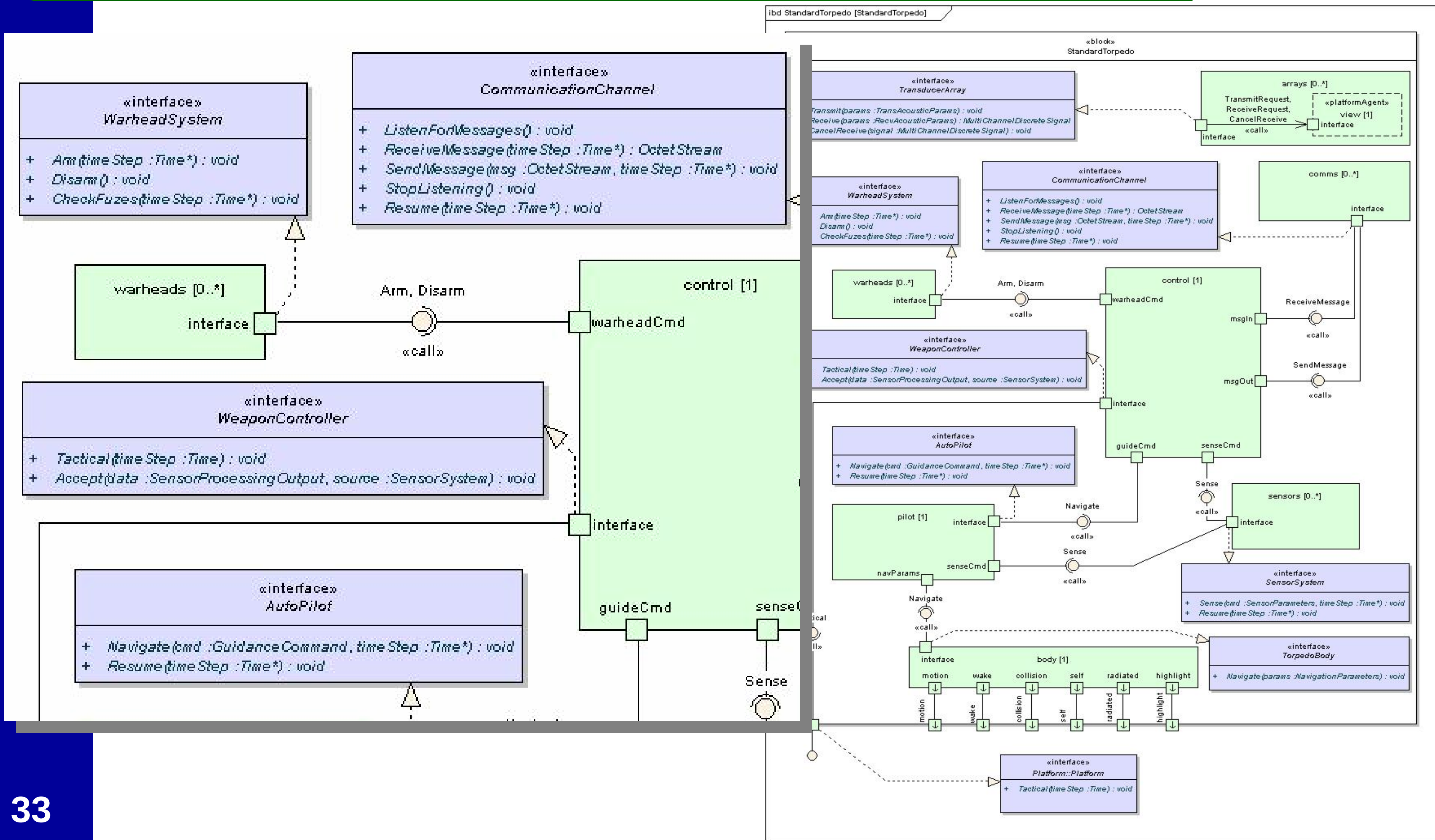
Pros

- Requirements
  - Explicitly lay out requirements and consequences
- Views and Viewpoints
  - Can separate requirements and model views based on stakeholders concerns
- **Structure**
  - Ability for model structure to verify requirements
    - Can search for requirements that aren't verified
    - Can search for model components that aren't justified
  - Separation of structure from behavior
    - SysML BDDs vs. IBDs and Activities allow for clear separation
    - UML allows this, but easier to implement in SysML
- Behavior
  - Dashed line for activity flow is more aesthetically pleasing
    - vs. UML solid line

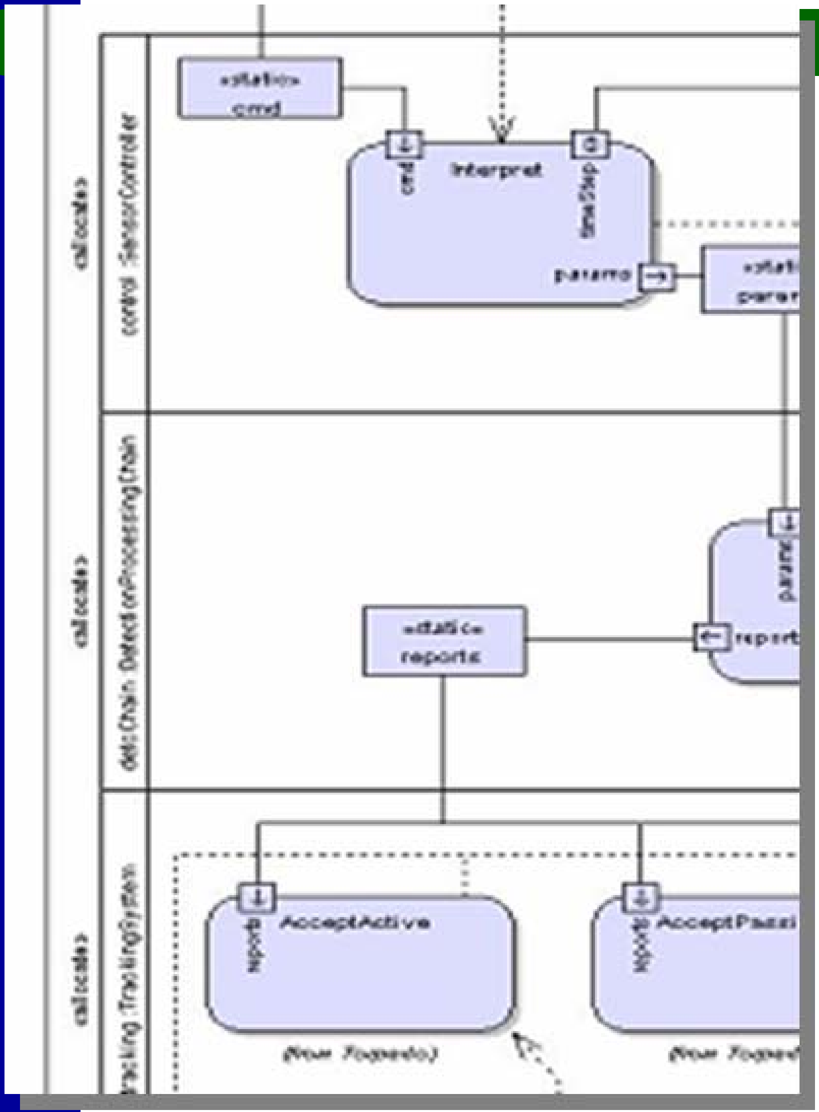
Torpedo Block Definition Diagram

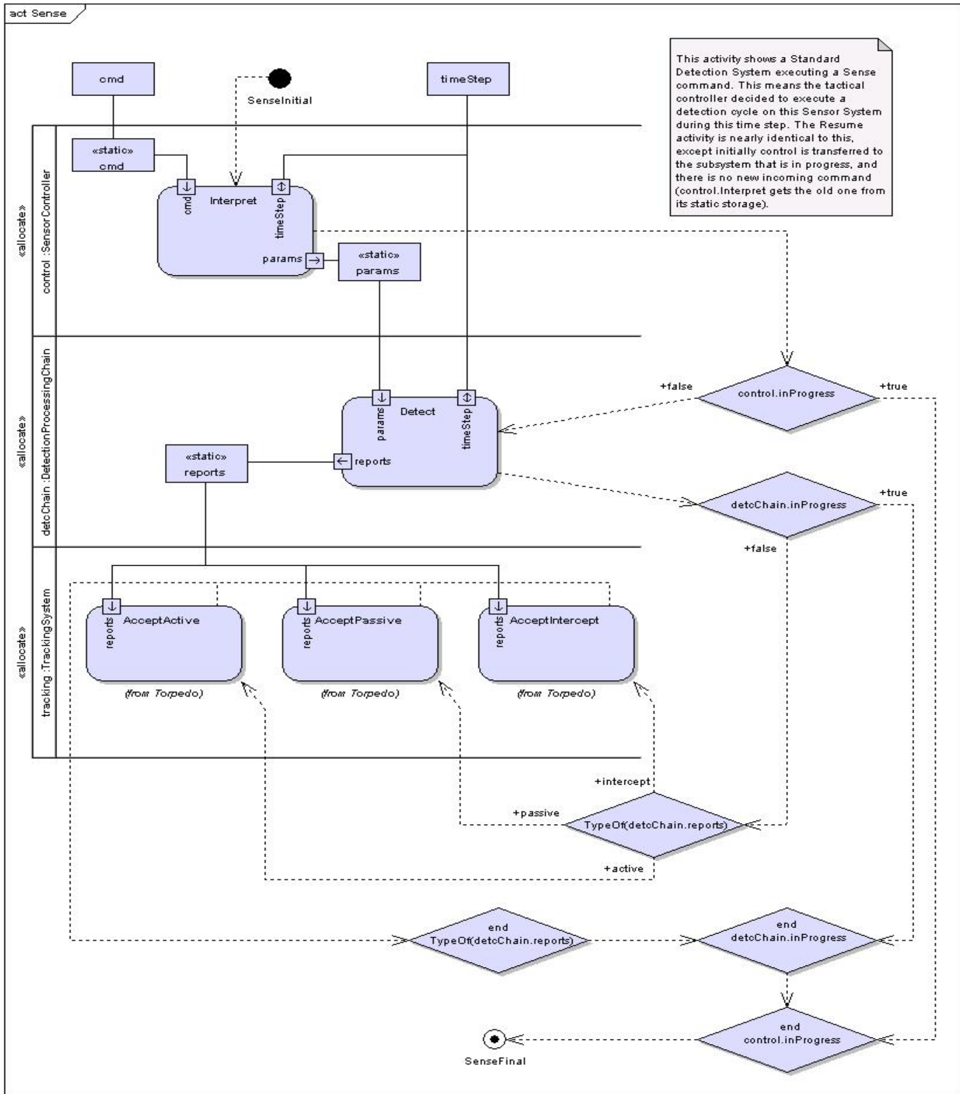


Torpedo Internal Block Definition Diagram

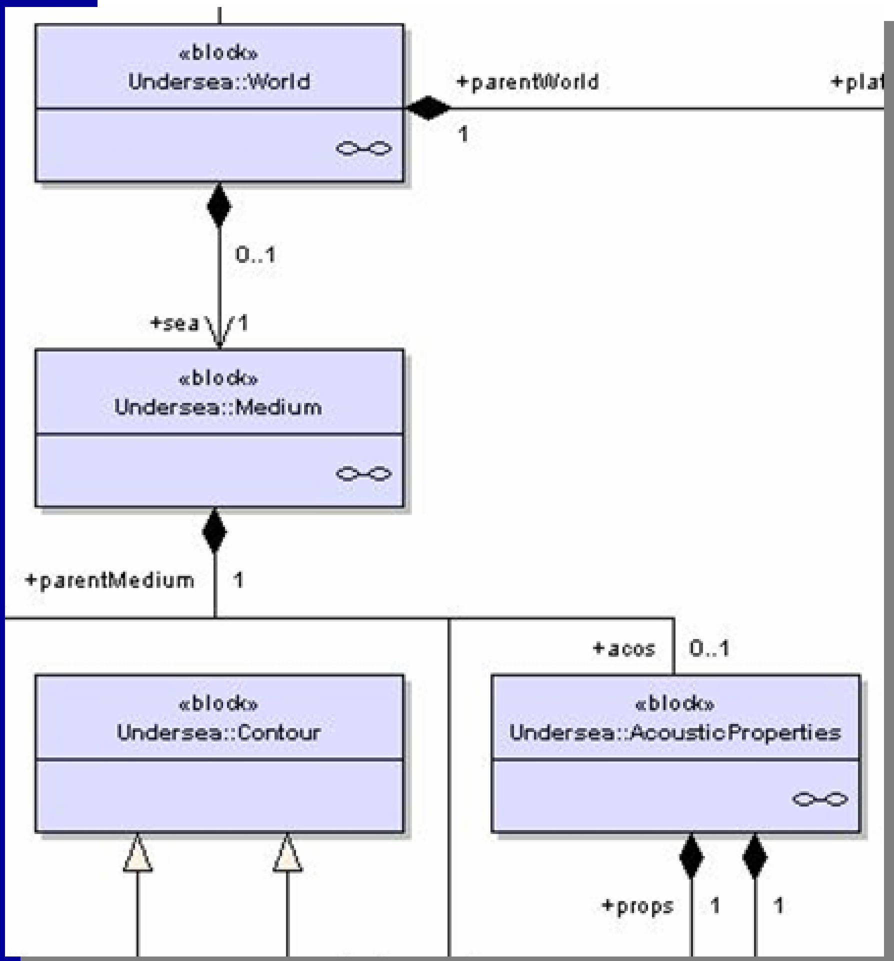


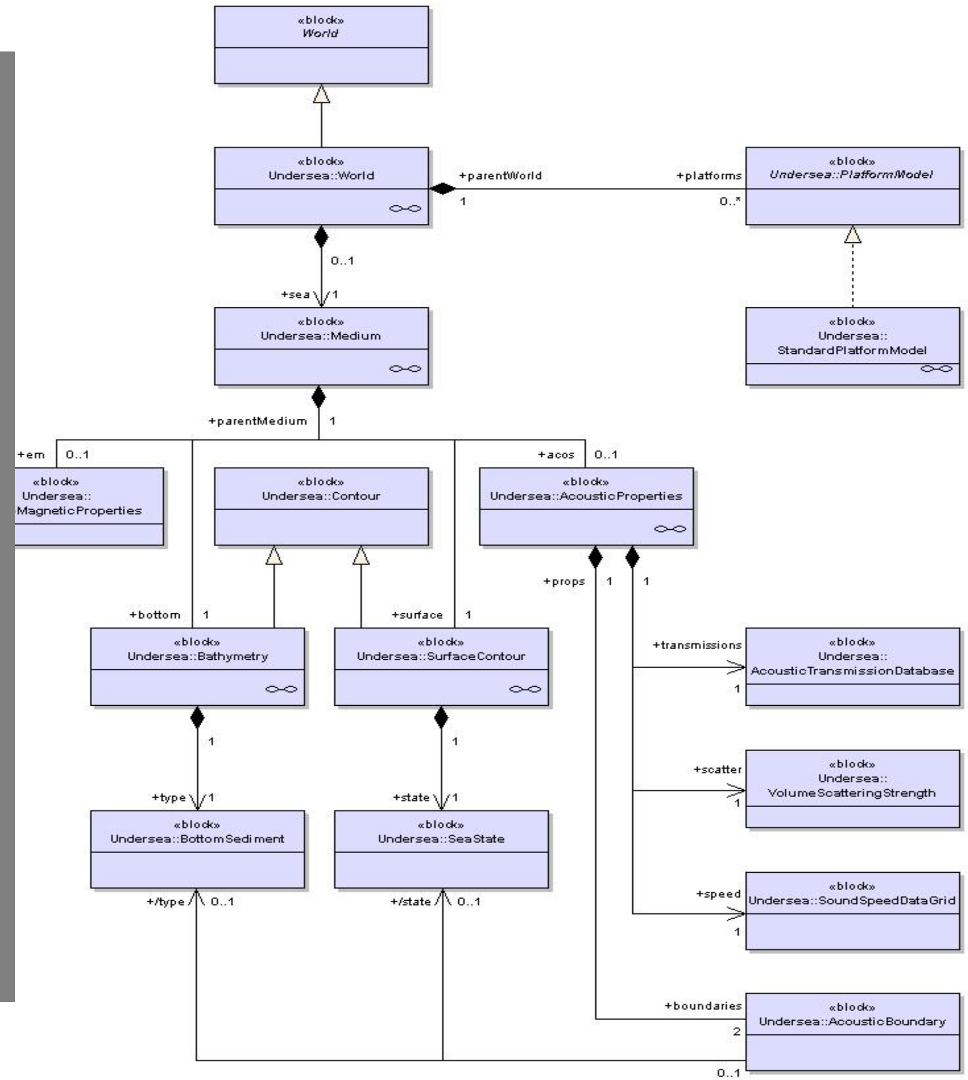
Torpedo Sensor Activity Diagram



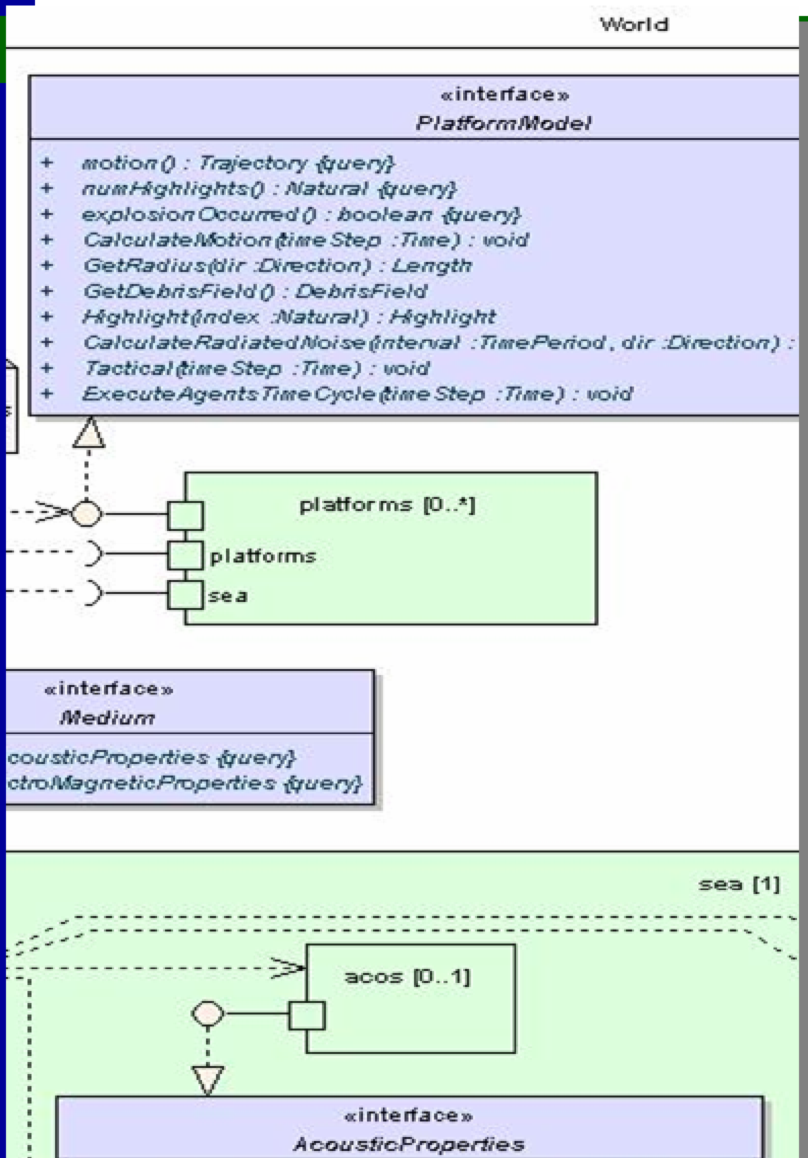


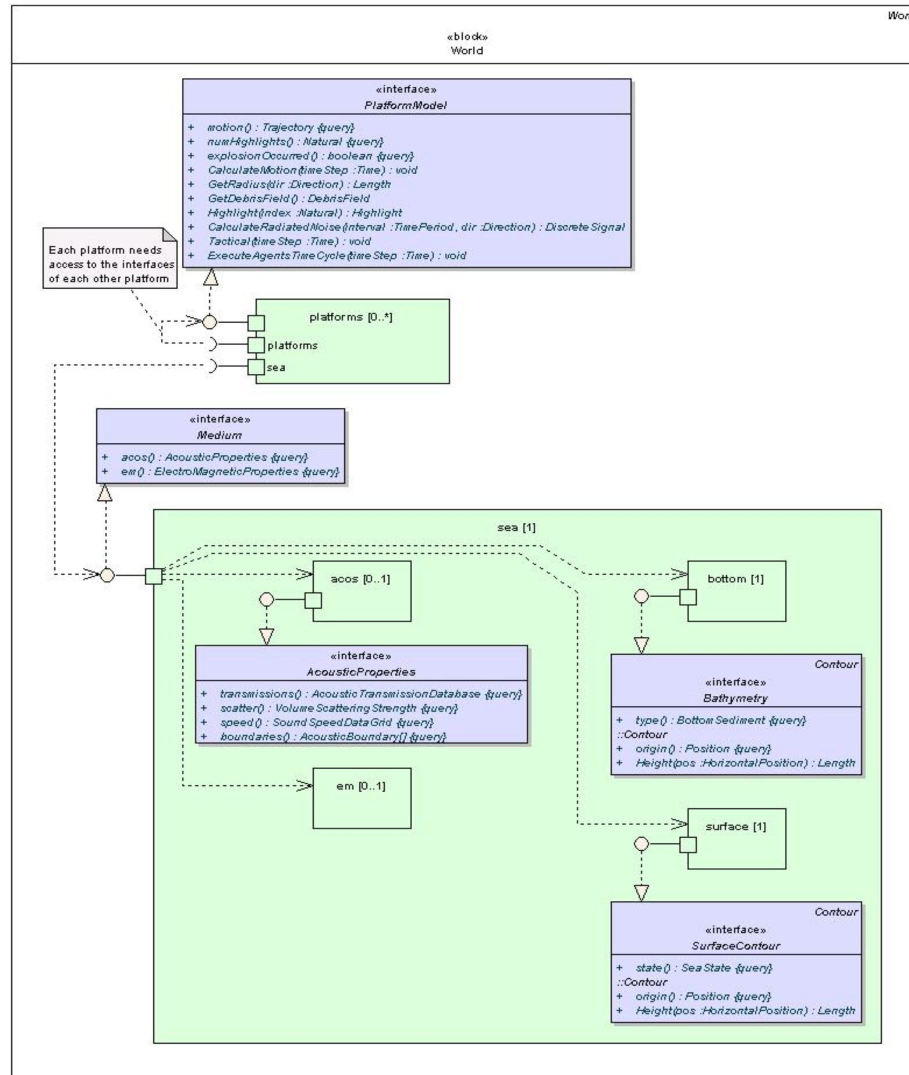
Undersea World Block Definition Diagram



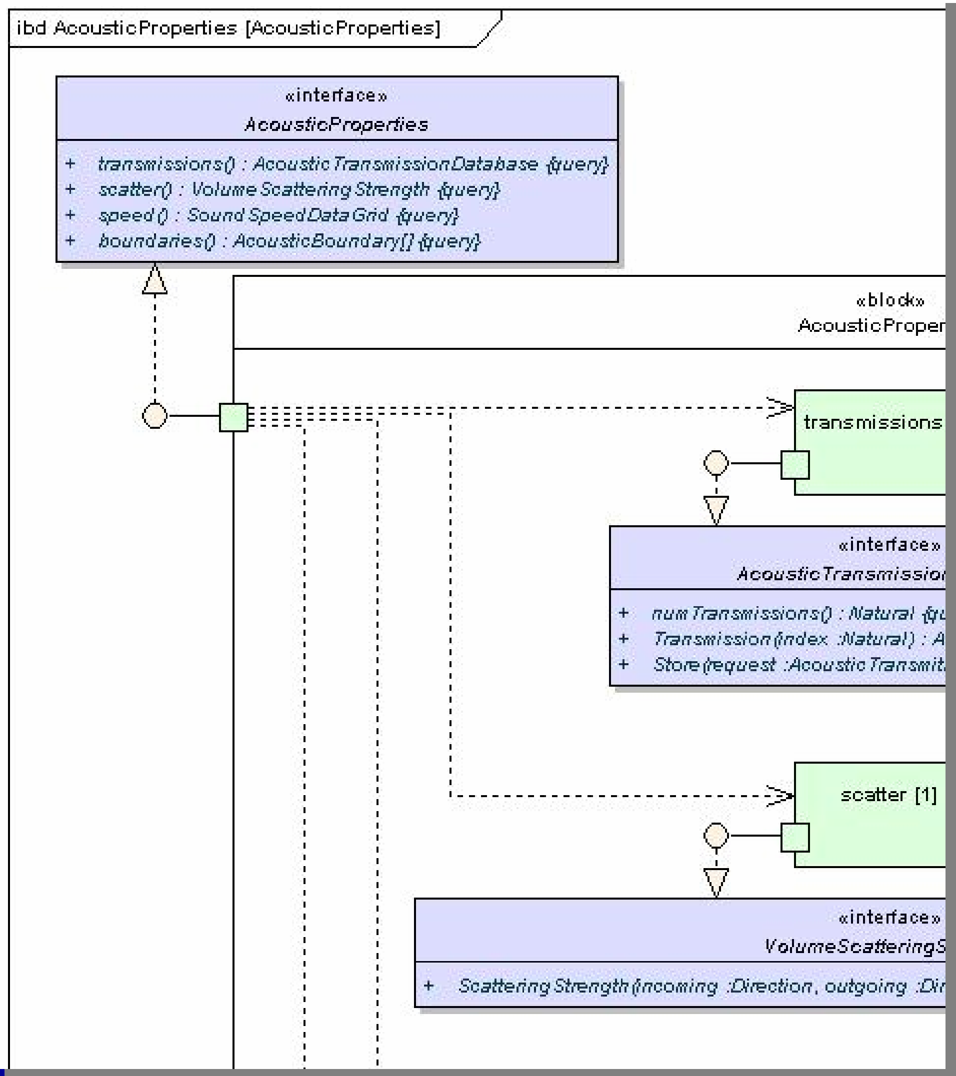


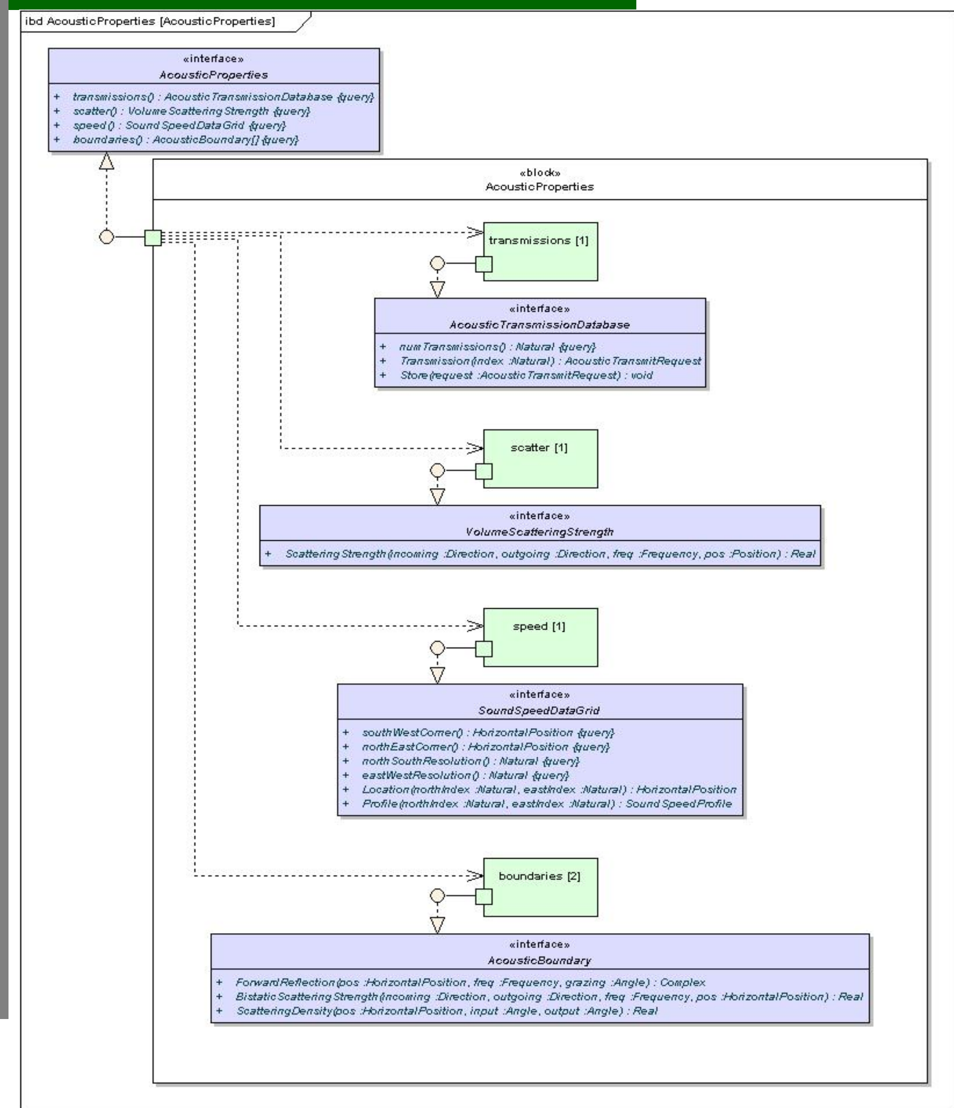
Simulation “World” Internal Block Definition Diagram





Acoustic Properties Internal Block Definition Diagram





TEAMS Perspective: SysML Pros

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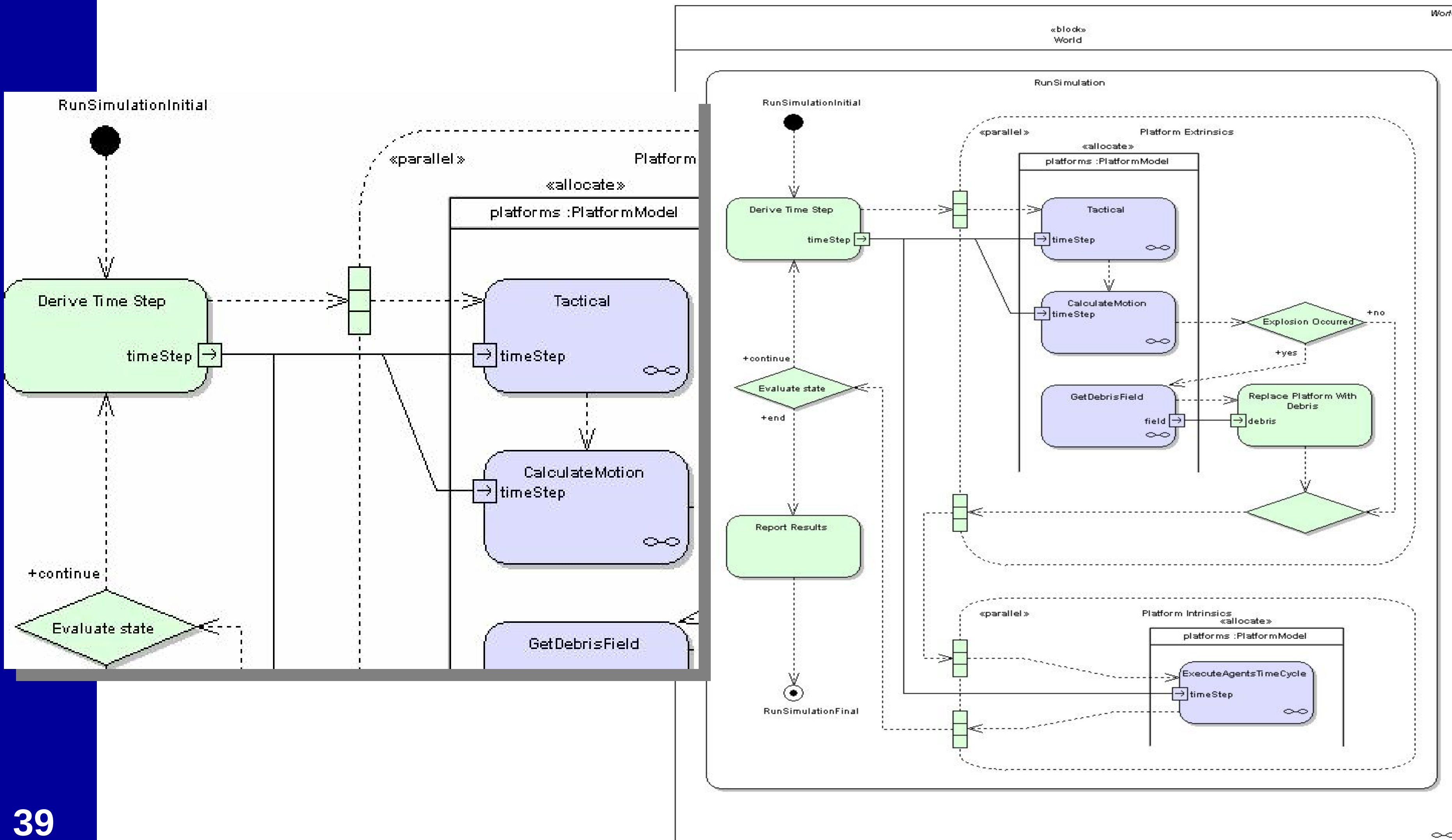
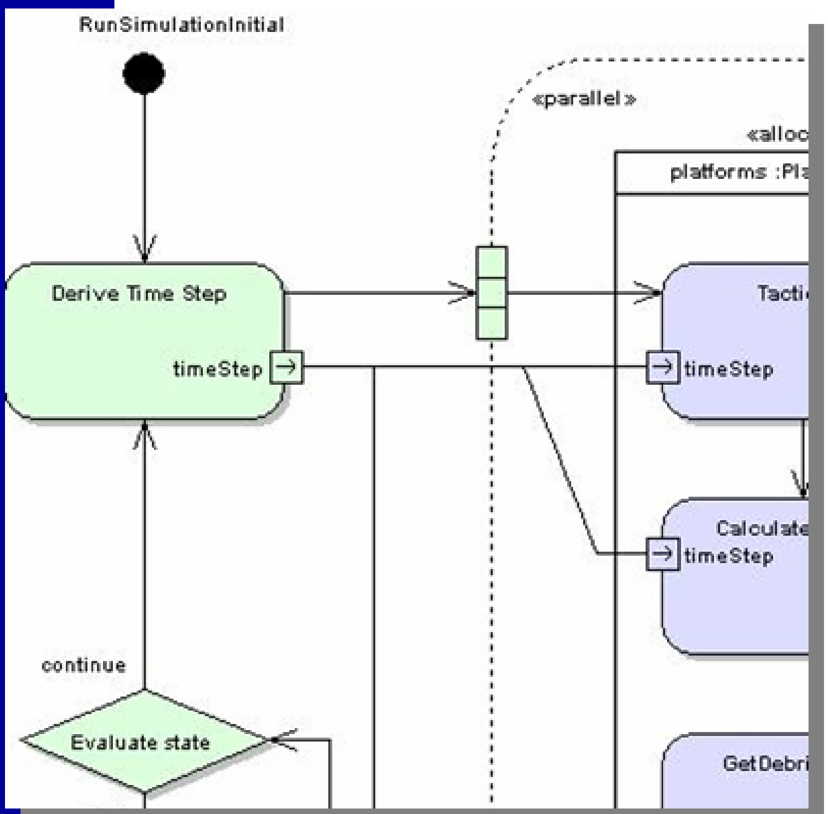
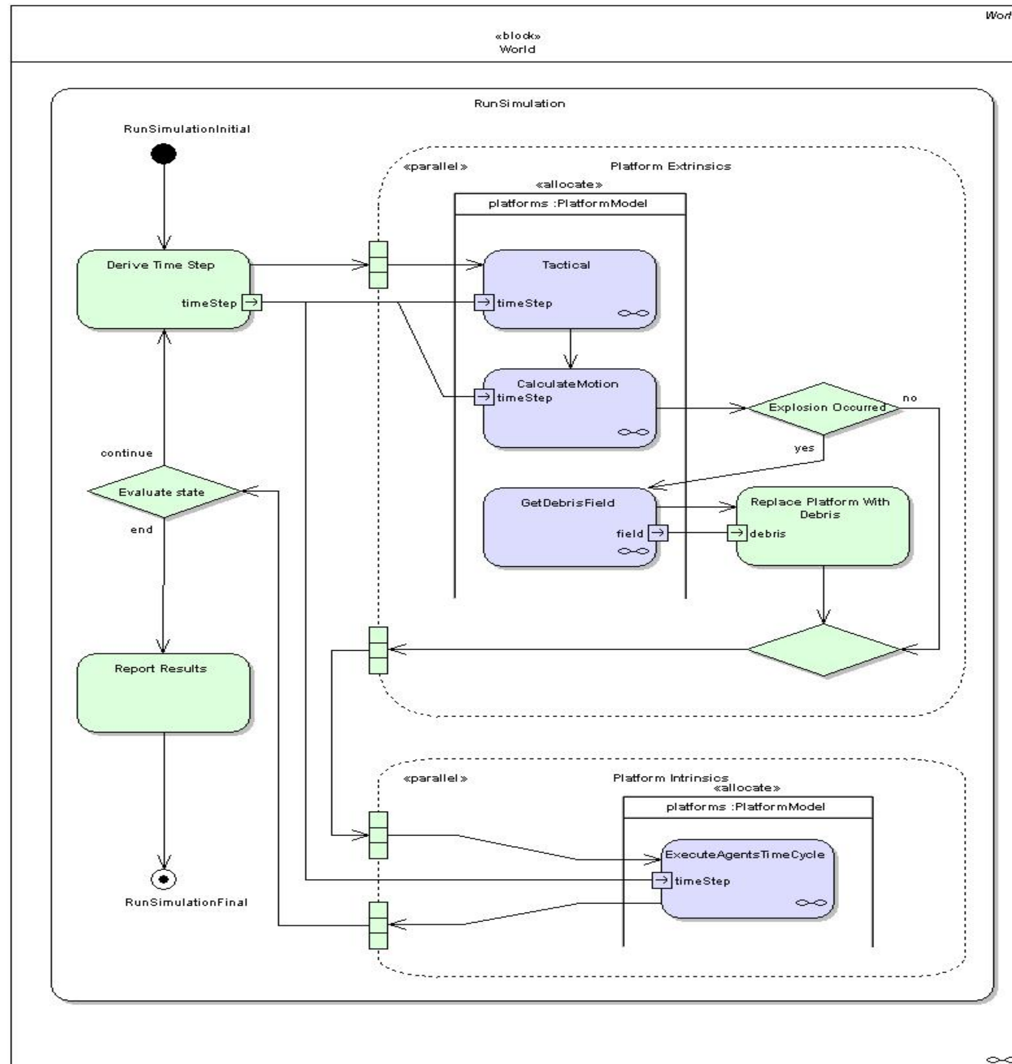
Simulation
“World” Activity Diagram



Solid Line Representation



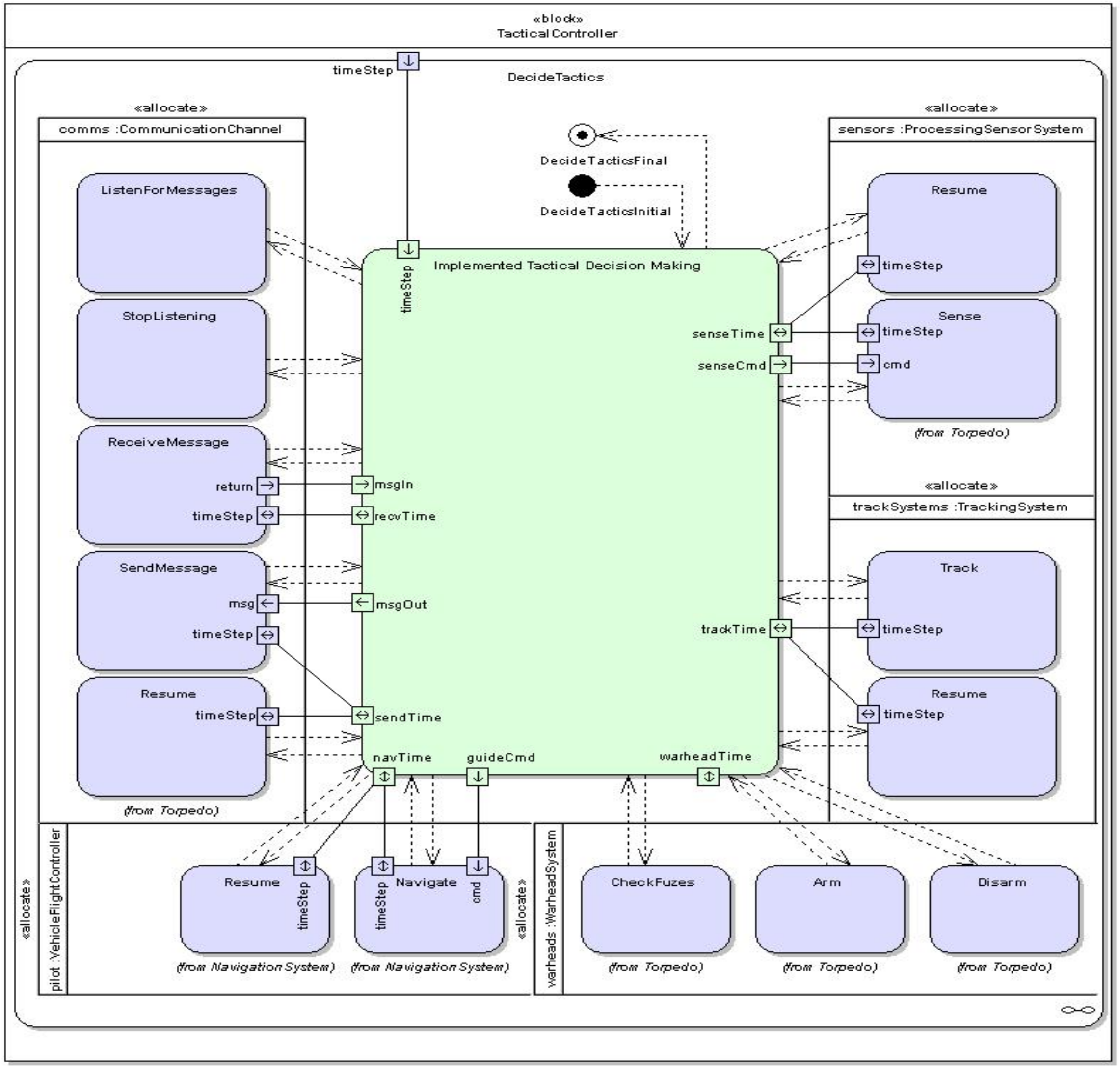


TEAMS Perspective: SysML Cons

Cons

- **Allocating CIM to PIM**
  - Difficulty with abstract activities
    - Exit path dependent on logic within an activity is not accessible and can't be modeled
    - Not represented well in either UML or SysML – tactical controller example
- **Implementing PIM**
  - Not "direct" for some SysML features
    - Flow ports, continuous activities, parametric constraints involve more components than just themselves
    - Flows in "real systems" easier to represent
    - Flows in software modeling are open to interpretation
  - Requires additional documentation of model to bridge between SysML feature and executable code

TEAMS Tactical Controller Example



TEAMS Perspective: SysML Cons

Cons

- Allocating CIM to PIM
  - Difficulty with abstract activities
    - Exit path dependent on logic within an activity is not accessible and can't be modeled
    - Not represented well in either UML or SysML – tactical controller example
- **Implementing PIM**
  - Not "direct" for some SysML features
    - Flow ports, continuous activities, parametric constraints involve more components than just themselves
    - Flows in "real systems" easier to represent than simulations
    - Flows in software modeling are open to interpretation
  - Requires additional documentation of model to bridge between SysML feature and executable code

Lessons Learned and Value Added

- Requirements traceability is ***vital*** to the success of several TEAMS projects
  - ONR TEAMS standard framework and interfaces
  - OSD-ATL feasibility study
  - TOGAF/MDA Synergy Project
- SysML was designed with "real" systems in mind
  - where UML is software oriented
- Perceived concreteness – simulated vs. actual system
  - not just one way to design interfaces, need recommendations for implementation
- Still need some UML features not present in SysML
  - <<Instantiate>> or <<create>> for dynamic allocation
- Still need guidance on how to best implement parametrics and constraints for modeling and simulation

OMG SE DSIG Recommendation

"Clarify the distinction between the domain model and the simulation design model."

*Reference SE DSIG minutes from OMG San Diego Meeting on March 27, 2007

Integrating SysML Models with Simulation Models

- Goal
  - Integrate system design models with simulation and analysis models
    - Use SysML models to specify an executable architecture
    - Use simulation and analysis models to analyze performance
- How can they work together ?
  - Plug the SysML executable architecture model into a simulation infrastructure to establish a dynamic interface
  - Use the executable architecture model to control the sequence of activities (e.g. detect target, launch weapon)
  - Use the simulation model to compute the parameter values (e.g. missile range to target vs. time)
- What is needed?
  - Approach to use SysML architectural model to specify simulation requirements (use of parametrics?)
  - Harmonization between SysML and simulation standards (i.e. HLA) ?

Source: Sanford Friedenthal, Lockheed Martin, OMG SE DSIG Chair - Recommendation to TEAMS Project

Future Direction

Working to Establish an Activity for SysML / Simulation Integration Approach

- Formulation/establishment during INCOSE MBSE Workshop in Albuquerque on January 24-25
- Liaison to the INCOSE Model Base Systems Engineering (MBSE) Initiative
- Keep abreast of industry related activities
- Help to foster interaction in this area across industry, government and academia to help move towards the INCOSE MBSE Vision.
- Explore this integration through SISO.

Acknowledgements

- LtCol Telford / Dwayne Hardy and OSD-ATL; supported and funded this effort for FY07
- David Drumheller and ONR; supports and funds TEAMS
- Sanford Friedenthal of Lockheed Martin; contributed his expertise and willingness to educate the TEAMS consortium on the nuances of SysML
- Members of The Open Group, Object Management Group, and TEAMS Consortium; contributed to the success of SysML Project
- Sparx Systems; provided complimentary licenses for Enterprise Architect 6.5 for this SysML effort

References

- Armstrong, C., Cerenzia, J., Harrington, E., Rivett, P., Waskeiwicz, F., , TOGAF/MDA/IC Synergy Project: Integration Proof-of-Concept Results, Proceedings of the Global Information Summit 2007.

  Avalable:

  http://www.omg.org/docs/omg/07-05-01.pdf
- Cerenzia, J. L., Scrudder, R.; Goddard, R. P., Haley, T. B., Lounsbury, D. M., Practical Experiences in Creating Components from Legacy Simulations, Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), 2005.

  Avalable:
  http://ntsa.metapress.com/app/home/contribution.asp?referrer=parent&backto=issue,111,153;journal,2,7;linkingpublicationresults,1:113340,1

SE for S&T

Applications of System Engineering to Pre-Milestone A Projects

Lori F Zipes

NSWC-PC Panama City FL

Agenda

- What does “Pre-Milestone A” mean?
- Can you do SE at this point?
- Why should you do SE at this point?
- How do you do SE at this point?

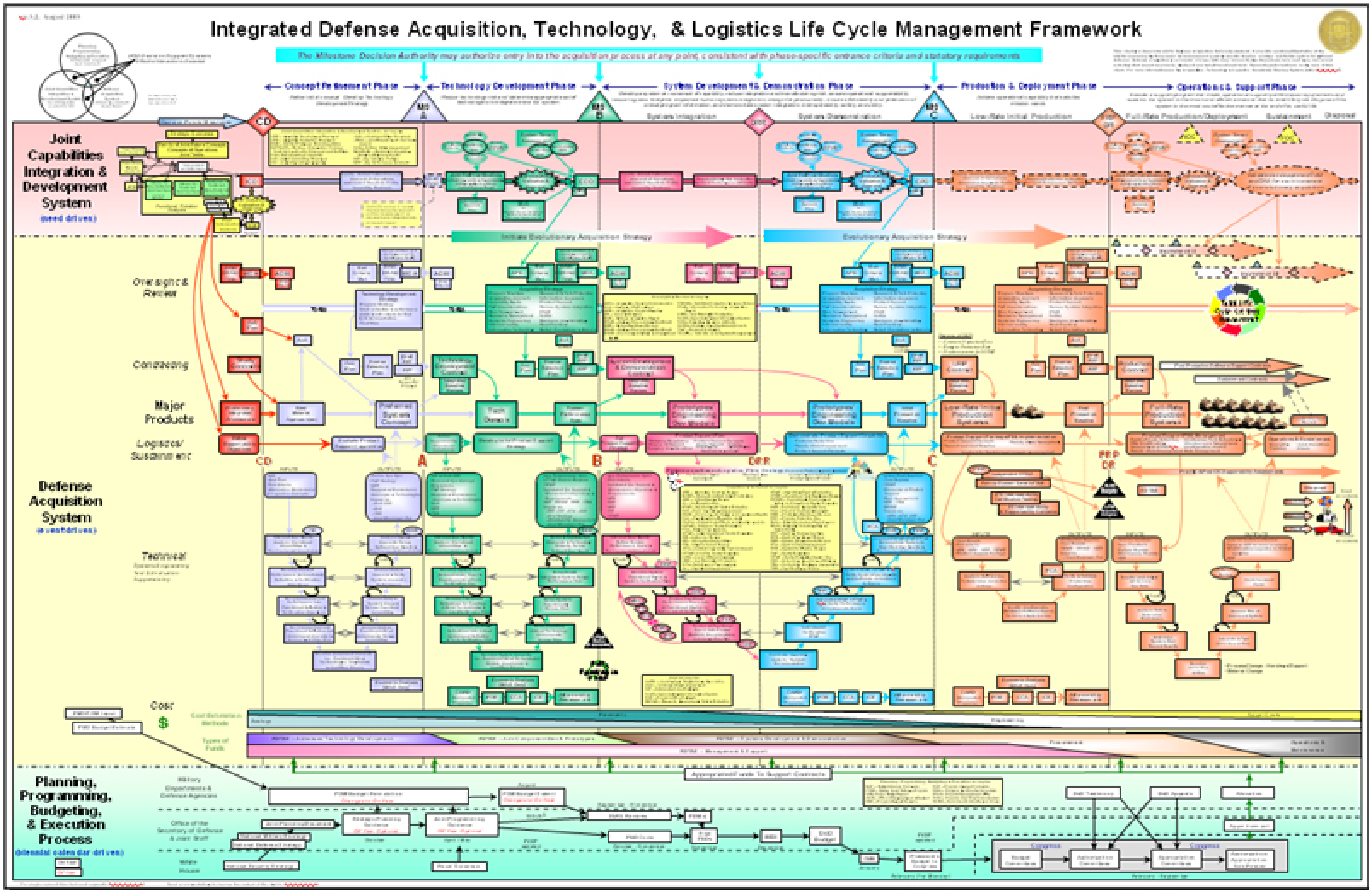
Pre-Milestone A

A DoD term that captures the concept development and concept refinement stages

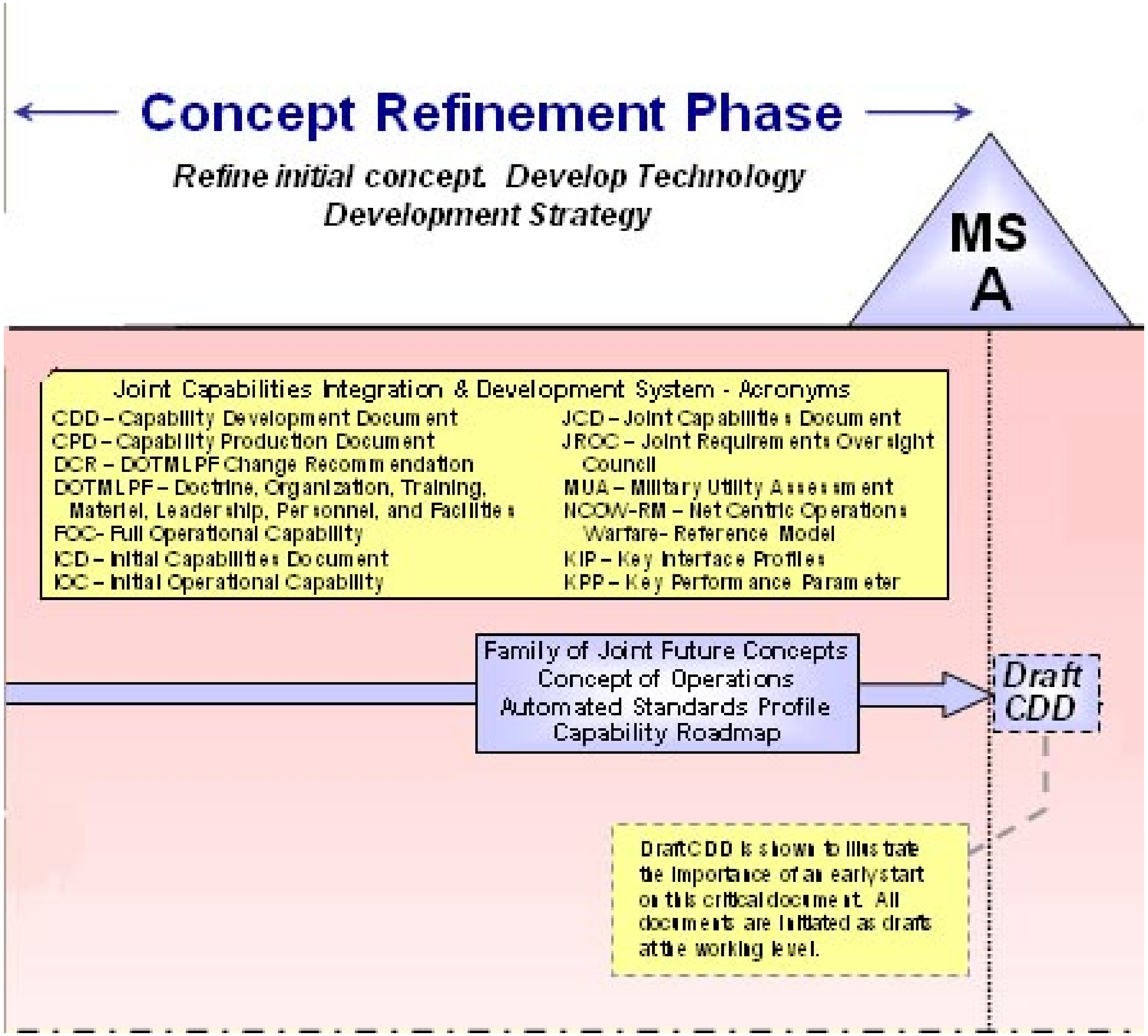
INCOSE (handbook/15288) equivalent is "Concept" stage

Often known in industry as "Study Period"

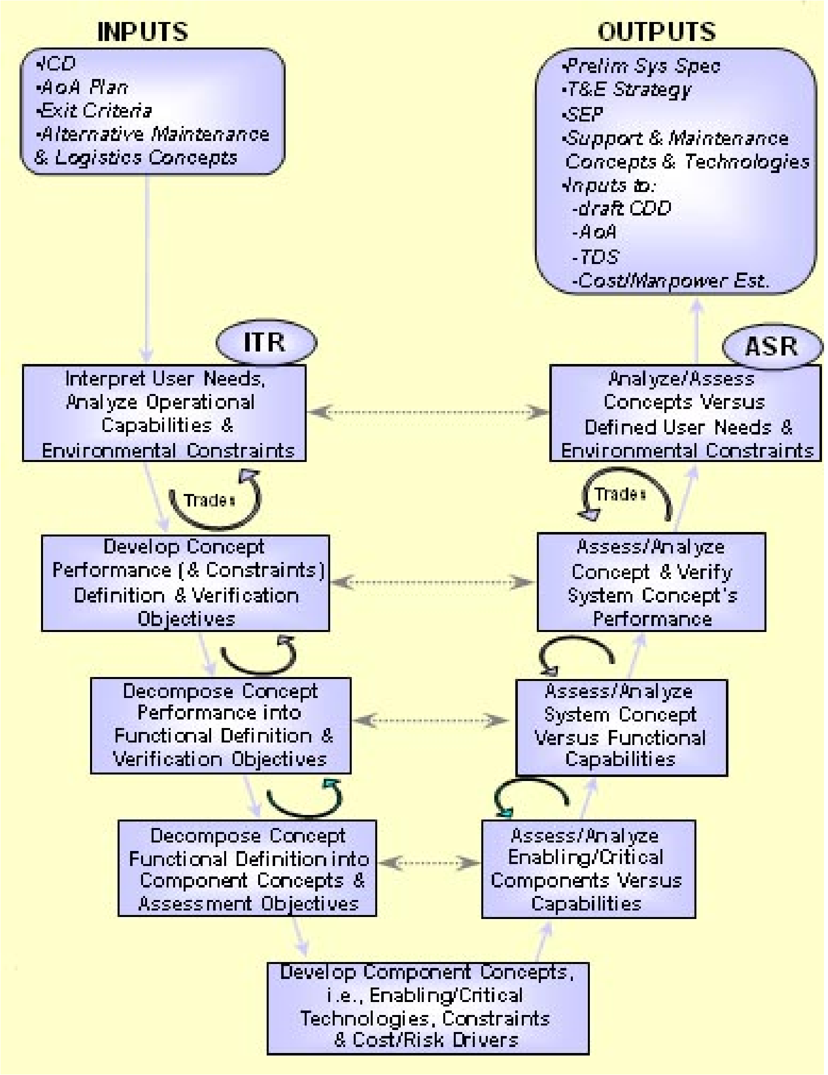
JCIDS "wall chart"



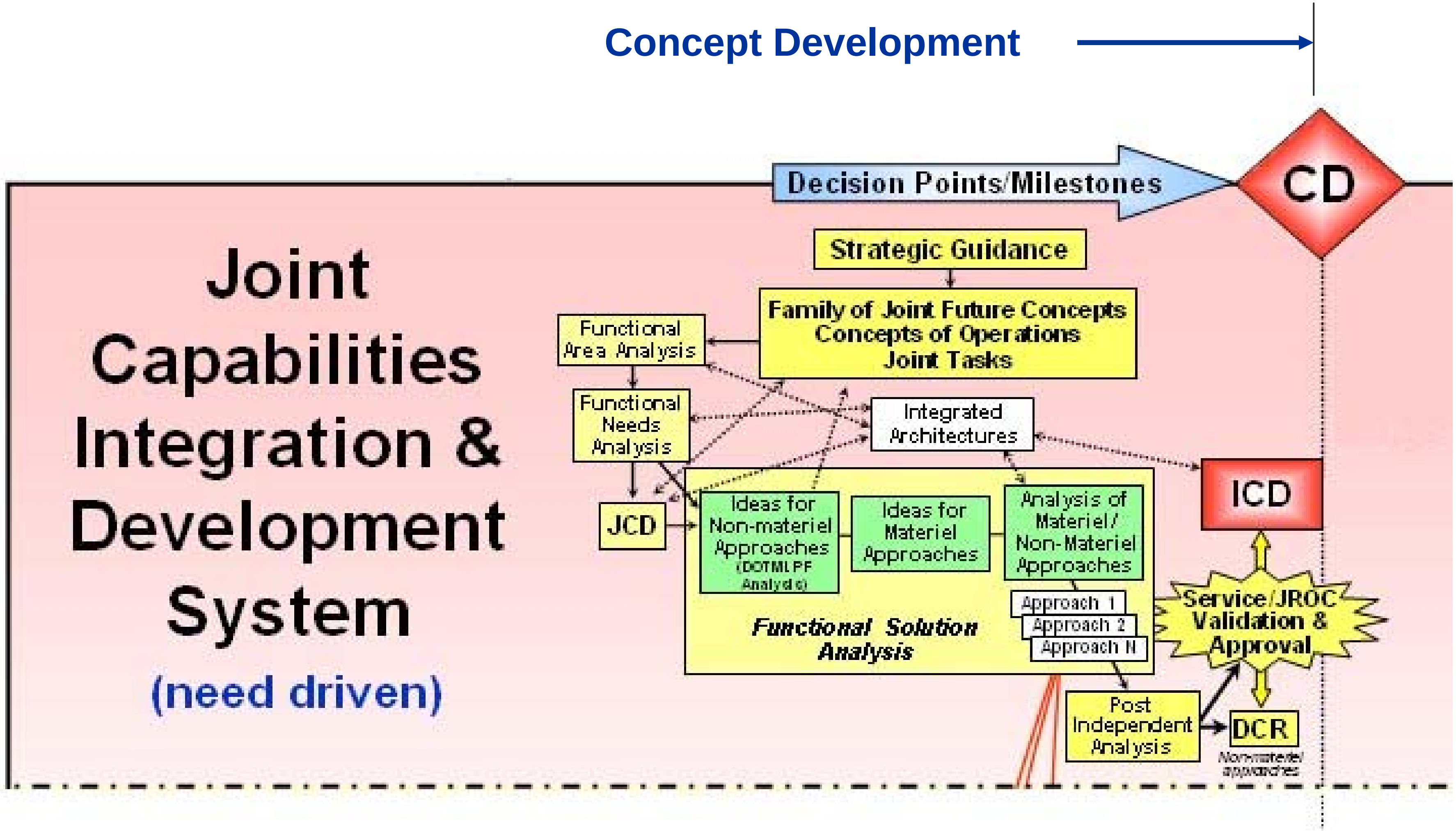
Zoom to Pre MS A



Pre MS A engineering aspects



Zoom to *before* Pre MS A



Can you do SE at this point?

- Not a lot of people do….

Can you do SE at this point?

- Not a lot of people do….

….but, YES!

Why should you do SE at this point?

- Typical Pre- MS A situation:
  A. A new technology looking for a problem
  B. A problem with a potential solution concept that leverages one or more technologies. There is a vision that needs some detailing and proving.

Why should you do SE at this point?

- Q. So why can't you just "play around" with the ideas & technologies until you get them robust enough to warrant "real" system engineering activities?

- A. You can, but you might miss out on some important things.

Common Vision

- Do all team members understand the end goal?
- Is there a documented “big picture” technical approach?

A notional example

- New concept to use underwater ultrasound to measure ship hull thickness
  - Transducer mfr
  - COTS scope
  - Cables & misc COTS/custom as needed

But

- If the transducer mfr is not aware this will be diver-held, he may make something with great resolution, but unmanageably large.
  - He needs the big vision so he can make proper development tradeoffs, even within his own “sandbox”

But

- If you don’t do good requirements development, you might find out too late that divers have certain racks or cases all their equipment fits into, and the scope you chose does not fit!

But

- If you don't talk to a logistician, you won't know that there is a hull cleaning system that you might easily attach to or integrate with, making your concept <u>much</u> more attractive to users.

How to do SE at this point

- Things to focus on:
  - System Engineering Plan *to include:*
  - Requirements Development
  - Configuration Management
  - Risk Management
  - Quality Assurance

SEP

- Follow the OSD guidance: Systems Engineering Plan Preparation Guide

http://www.acq.osd.mil/se/publications.htm

Section 3 will guide you through.

The plan need not be burdensome.

Evolve it as you progress.

Requirement Development

- Identify and document the source of your requirements, then determine if you really have them all!
- How did you, or will you, validate them (who are your users and stakeholders?)
- How will you manage them?
- *Do you need to, or want to "architect" your system?*

Configuration Management

- Identify what types of info require CM
  - SEP, Proj Plan, Work Packages, Reqmts
  - Final Reports, Design Baselines
- Plan for version control (1.x or date or…)
- Define a review/change/approval process
- Where will they be stored?

Sample CM content

Document Title	**Author**	**Signature Authority**
Project Plan	PM	Sponsor
Systems Engineering Plan	Lead Systems Eng.	PM
User Requirements Doc	Systems Engineer	Sponsor

This list will be updated as needed during execution of the project. Documents subject to formal configuration control will be required to pass through peer review and signature for both initial generation and any subsequent revisions. Formality and breadth of the peer review will be at the discretion of the document author with concurrence from the signature authority. All formal configuration controlled documents will include version and date information on the title page, and a revision history page. Version numbers shall be 0.X until first signature approval. Thereafter minor revisions shall be numbered by iterating the numeral to the right of the decimal, major revisions shall increment the number to the left of the decimal.

The Project Manager shall be responsible for maintaining accurate knowledge of and access to the most current version of each formally controlled project document.

General configuration control for all working level documents will be executed via the use of a collaborative data site. Users will be responsible for maintaining current versions of documents they post for team use. The team will utilize the site as the primary source for working level information, to minimize version control issues created by the e-mailing or other uncontrolled distribution of documents.

As this project advances, a more robust configuration management process may be required, to include specific tools. This section will be updated accordingly at that time.

Risk Management

- Consider: schedule, cost, resources, **technical**
- Suggestion: PM identifies schedule, cost & resource risks. SMEs identify technical risks.
- Plan for assessment, mitigation…
- Suggestion: review risks at team meetings

Risk Information Form sample

Risk Information Form

Risk Identification Number		Date Entered:	
Risk Title:			
Priority:			
Statement of Risk			
Description of risk:			
Causes:			
Relationship to other risks:			
Probability of Occurrence:			
Consequence:			
Time Sensitivity (when mgiht risk occur):			
Risk Handling Plans:			
Status Information:			

Risk Information Form

Risk Information Form

Risk Identification Number	SNS_RI-001	Date Entered: 06 June 06
Risk Title:	Un-approved requirements	
Priority:	Medium	

Statement of Risk

Description of risk:

Requirements remain unapproved/prioritized by the user community. Several remain poorly defined: “in stride” breaching capability, geographic location for environmental specifics.

Some are of questionable/unclear importance: very small mine (<6”) neutralization / success rates, command detonation requirement.

Causes:

Broad search was done to gather requirements, some findings conflict, some are lacking verifiable source, have not yet had the opportunity to vet with operational community to resolve these issues

Relationship to other risks:

Uncertainty of requirements impact decision making, particularly during tradeoff efforts

Probability of Occurrence:	B	Unlikely
Consequence:	D	Major Impact
Time Sensitivity (when mgiht risk occur):		4Q 2006

Risk Handling Plans:

Continue effort to make contact with operational community. If no validation meetings have been scheduled by 15 Sept 2006, inform sponsor of situation.

Status Information:

09/11/06 Contact made with Route Clearance Training school at Ft Leonard Wood, MO (Army); tentative requirements validation meeting week of 10 Oct 2006. Contact made with MCES Lejeune NC (USMC); tentative requirements validation meeting week of 27 Sept 2006.

Quality Assurance

- Suggestion: Set basic standards for things like meeting agendas, minutes, action items & follow up

Don’t make them burdensome, but have some simple expectations & make sure they are followed.

Other thoughts…

- Strongly recommend periodic team meetings, particularly if team is geographically dispersed.
- Don’t make any of the “process” work unnecessarily burdensome. Use common sense, follow SE <u>principles</u>.

Parting Thought

"Plan your dive; dive your plan"

Questions, comments?

Program Management vs Systems Engineering

How different are they?

Lori F Zipes
NSWC-PC
Panama City, FL

Overview

- PMBoK review
- DAU Guidebook review
- INCOSE handbook review (15288)
- What are the PM's goals, the SE's goals?
- What should a PM do, what should an SE do?
- PM skills, SE skills
- Can one person do both?

Perspective for this presentation

- DoD
- Technical Programs (heavy SE role)
- Possible R&D bias (mine)

PMBoK (3rd Ed 2004)

- 44 “Project Management Processes”
- Each is associated with one of 5 “Project Process Groups”

Initiating, Planning, Executing, Monitoring, Controlling

- Each is also associated with one of 9 “Knowledge Areas”

Integration, Scope, Time, Cost, Quality, Human Resource, Communications, Risk and Procurement Management

Let’s look at those 44 processes...
...very quickly

KA 4. Project Integration Management

- 4.1 Develop Project Charter
- 4.2 Develop Preliminary Project Scope Statement
- 4.3 Develop Project Management Plan
- 4.4 Direct and Manage Project execution
- 4.5 Monitor and Control Project Work
- 4.6 Integrated Change Control
- 4.7 Close Project

KA 5. Project Scope Management

- 5.1 Scope Planning
- 5.2 Scope Definition
- 5.3 Create WBS
- 5.4 Scope Verification
- 5.5 Scope Control

KA 6. Project Time Management

- 6.1 Activity Definition
- 6.2 Activity Sequencing
- 6.3 Activity Resource Estimating
- 6.4 Activity Duration Estimating
- 6.5 Schedule Development
- 6.6 Schedule Control

KA 7. Project Cost Management

- 7.1 Cost Estimating
- 7.2 Cost Budgeting
- 7.3 Cost Control

KA 8. Project Quality Management

- 8.1 Quality Planning
- 8.2 Perform Quality Assurance
- 8.3 Perform Quality Control

KA 9. Project Human Resource Management

- 9.1 Human Resource Planning
- 9.2 Acquire Project Team
- 9.3 Develop Project Team
- 9.4 Manage Project Team

KA 10. Project Communications Management

- 10.1 Communications Planning
- 10.2 Information Distribution
- 10.3 Performance Reporting
- 10.4 Manage Stakeholders

KA 11. Project Risk Management

- 11.1 Risk Management Planning
- 11.2 Risk Identification
- 11.3 Qualitative Risk Analysis
- 11.4 Quantitative Risk Analysis
- 11.5 Risk Response Planning
- 11.6 Risk Monitoring and Control

KA 12. Project Procurement Management

- 12.1 Plan Purchases and Acquisitions
- 12.2 Plan Contracting
- 12.3 Request Seller Responses
- 12.4 Select Sellers
- 12.5 Contract Administration
- 12.6 Contract Closure

DAU Defense Acquisition Guidebook

- Designed to compliment DoDD 5000.1 and DoDI 5000.2 “by providing the acquisition workforce with discretionary best practice...”

  a how-to guide

- Program Management (DoD style) is throughout the document
- Chapter 4 is Systems Engineering in specific *...so we’ll look at that a bit*

DAU Guidebook Ch 4 - SE

- Technical <u>Management</u> Processes:
  - Decision Analysis
  - Technical Planning
  - Technical Assessment
  - Requirements Management
  - Risk Management
  - Configuration Management
  - Technical Data Management
  - Interface Management

some of these look familiar...

DAU Guidebook Ch 4 - SE

- Technical Processes:
  - Requirements Development
  - Logical Analysis
  - Design Solution
  - Implementation
  - Integration
  - Verification
  - Validation
  - Transition

DAU Guidebook Ch 4 - SE

- Also mentioned:
  - Quality
  - Master Plan / Schedule

these ring a bell also...

INCOSE SE Handbook V3

- Technical Processes (Ch 4)
- Project Processes (Ch 5)
- Enterprise and Agreement Processes (Ch 6)

Consistent with ISO/IEC 15288

INCOSE SE Handbook V3

- Technical Processes
  - Stakeholder Requirements Definition
  - Requirements Analysis
  - Architectural Design
  - Implementation
  - Integration
  - Verification
  - Transition
  - Validation
  - Operation
  - Maintenance
  - Disposal

very similar to DAU Guide technical processes

INCOSE SE Handbook V3

- Project Processes
  - Project Planning
  - Project Assessment
  - Project Control
  - Decision Making
  - Risk and Opportunity Management
  - Configuration Management
  - Information Management

quite similar to DAU Guide technical management processes, which were similar to PMBoK

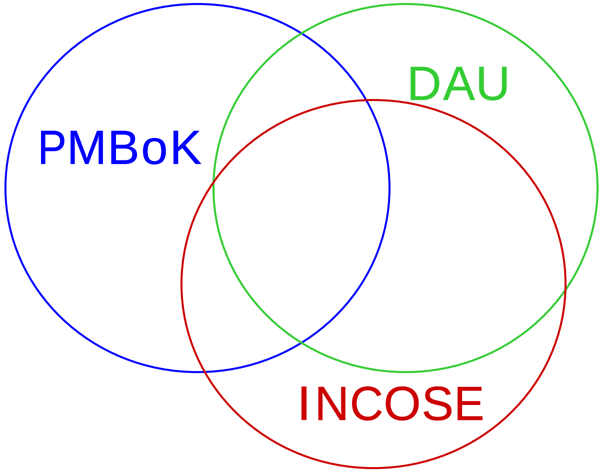
INCOSE SE Handbook V3

- Enterprise and Agreement Processes
  - Enterprise Environment Management
  - Investment Management
  - System Life Cycle Process Management
  - Resource Management
  - Quality Management
  - Acquisition
  - Supply

a few more familiar terms…

PMBoK vs DAU vs INCOSE Hdbk

So who does what?



PMBoK	DAU	INCOSE
4.1Develop Project Charter	Technical Planning	Project Planning, SLC Process Mgmt, Investment Mgmt
4.2 Develop Preliminary Project Scope Statement	Technical Planning	Project Planning, SLC Process Mgmt
4.3 Develop Project Management Plan	Technical Planning	Project Planning, Resource Mgmt, Investment Mgmt
4.4 Direct and Manage Project execution	Decision Analysis	Project Assessment, Project Control
4.5 Monitor and Control Project Work	Technical Assessment	Project Assessment, Project Control, Decision making
4.6 Integrated Change Control	Configuration Mgmt, Tech Data Mgmt	Project Assessment, Project Control, Configuration Mgmt
4.7 Close Project		Project Control
5.1 Scope Planning	Technical Planning	Project Planning, Enterprise Environment Mgmt, SLC Process Mgmt
5.2 Scope Definition	Technical Planning	Project Planning
5.3 Create WBS	Technical Planning	Project Planning
5.4 Scope Verification	Technical Assessment	Project Assessment, Enterprise Environment Mgmt
5.5 Scope Control	Decision Analysis, Technical Assessment	Project Control

PMBoK	DAU	INCOSE
6.1 Activity Definition	Technical Planning	Project Planning
6.2 Activity Sequencing	Technical Planning	Project Planning, Decision Making
6.3 Activity Resource Estimating	Technical Planning	Project Planning, Resource Mgmt
6.4 Activity Duration Estimating	Technical Planning	Project Planning
6.5 Schedule Development	Technical Planning	Project Planning
6.6 Schedule Control	Technical Assessment	Project Control, Decision making
7.1 Cost Estimating	Technical Planning	Project Planning
7.2 Cost Budgeting	Technical Planning	Project Planning, Resource Mgmt
7.3 Cost Control	Technical Planning	Project Control, Decision making, Resource Mgmt
8.1 Quality Planning	Technical Planning	Project Planning, Quality Mgmt
8.2 Perform Quality Assurance	Quality	Configuration Mgmt, Quality Mgmt
8.3 Perform Quality Control	Quality	Project Control, Quality Mgmt

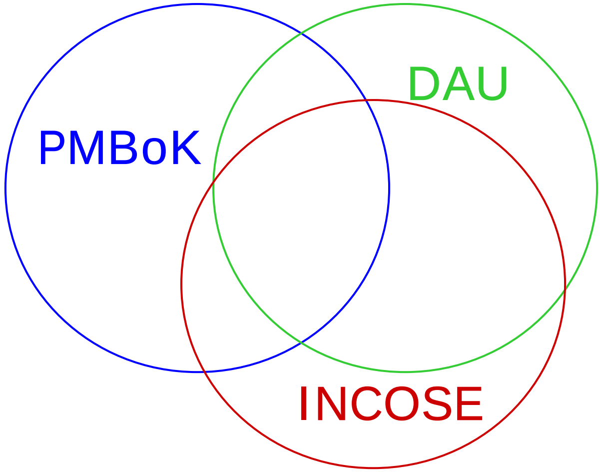
PMBoK	DAU	INCOSE
9.1 Human Resource Planning	Technical Planning	Project Planning, Enterprise Environment Mgmt, Resource
9.2 Acquire Project Team		Enterprise Environment Mgmt, Resource Mgmt
9.3 Develop Project Team		Resource Mgmt
9.4 Manage Project Team		Project Control, Resource Mgmt
10.1 Communications Planning	Tech Data Mgmt	Project Planning, Information mgmt
10.2 Information Distribution	Tech Data Mgmt	Information mgmt
10.3 Performance Reporting	Tech Data Mgmt	Information mgmt
10.4 Manage Stakeholders		Enterprise Environment Mgmt
11.1 Risk Management Planning	Technical Planning, Risk Mgmt	Project Planning, Risk and Opportunity Mgmt
11.2 Risk Identification	Risk Mgmt	Risk and Opportunity Mgmt
11.3 Qualitative Risk Analysis	Risk Mgmt	Project Assessment, Risk and Opportunity Mgmt, Decision making
11.4 Quantitative Risk Analysis	Risk Mgmt	Project Assessment, Risk and Opportunity Mgmt, Decision making
11.5 Risk Response Planning	Technical Planning, Risk Mgmt	Project Planning, Risk and Opportunity Mgmt, Resource Mgmt
11.6 Risk Monitoring and Control	Risk Mgmt	Project Assessment, Risk and Opportunity Mgmt

PMBoK	DAU	INCOSE
12.1 Plan Purchases and Acquisitions	Technical Planning	Project Planning, Acqusition & Supply Processes
12.2 Plan Contracting	Technical Planning	Project Planning, Acqusition & Supply Processes
12.3 Request Seller Responses		Acqusition & Supply Processes
12.4 Select Sellers		Project Control, Decision making, Acqusition & Supply Processes
12.5 Contract Administration		Project Control, Acqusition & Supply Processes, Resource Mgmt
12.6 Contract Closure		Acqusition & Supply Processes

PMBoK	DAU	INCOSE
	Requirements Development	Stakeholder Requirements Definition
	Logical Analysis	Requirements Analysis
	Design Solution	Architectural Design
	Implementation	Implementation
	Integration	Integration
	Verification	Verification
	Validation	Validation
	Transition	Transition
		Operation
		Maintenance
		Disposal

PMBoK vs DAU vs INCOSE Hdbk

So (again) who does what?



PM vs SE: what are their goals?

- PM is accountable for the success of the entire program and all aspects of it.

- SE is responsible for the technical success of the program.

Some “clear” distinctions

These are “owned” by the PM:

Enterprise Environment Management
Investment Management
System Life Cycle Process Management

Some “clear” distinctions

These are “owned” by the SE:

Stakeholder Requirements Definition
Requirements Analysis
Architectural Design
Implementation
Integration
Verification
Validation
Transition
Operation
Maintenance
Disposal

Some “not so clear” distinctions

These are probably “owned” by the PM, but require inputs and assistance from the SE:

- Project Planning
- Project Assessment
- Project Control
- Decision Making
- Risk and Opportunity Management
- Configuration Management
- Information Management
- Resource Management
- Quality Management
- Acquisition
- Supply

Getting the Right People

- What makes a good PM?
- What makes a good SE?

A "good" PM – the Program Leader

- Is ideally a business or management major, or has a strong background & skills in these areas
- Beware the Technical major as PM!
  - Might get stuck "in the weeds," lack program level vision.
  - Tend to micromanage technical aspects.
  - Might get focused on technical problem and not make the best **programmatic** decision.
  - May not have the discipline to manage rigorously *(think CMMI: do "coders" like CMMI?)*

A “good” SE – the Technical Leader

- Is (hopefully!) a technical major
- Beware the Non-technical major who has some sort of SE role (or if there is no SE)
  - May lack ability to form and propagate an overarching technical vision
  - Might be more of a manager than a leader
  - Might not have the proper knowledge to resolve technical conflict or make/approve technical decisions.

PM vs SE perspectives

It is not necessarily bad for there to be a bit of friction between the two

...because sometimes the optimal technical solution is not the optimal programmatic solution

So, can one person do both?

- On a “small” program
- Very early in a program (even a big program)
- On a non-complex program
  - No hardware/software mix, single technology, few or no external interfaces...

Things to watch out for in these cases

- Need to get an individual with strong and broad technical knowledge and management skills
- Make sure they have a mental concept of their two “hats” and when they need to wear each one.

Perspective – a parting thought

- Both people need to appreciate the role of the other person, determine mutually agreeable dividing lines for their responsibilities.

Questions, comments?

Autonomic GIG Management & Security Agent Technology

10th Annual

NDIA System Engineering Conference

October 22-25, 2007

Don P. Cox, Missile Systems

Youssif Al-Nashif, University of AZ

Salim Hariri, PhD, University of AZ

(520) 794-8186) dcox@raytheon.com

Abstract # 5386

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Agenda

- The GIG
- Autonomia
- Attack Detection & Defense
- Conclusions

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Thank you !

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H P D C

High Performance Distributed Computing Laboratory

Salim Hariri, Ph.D.

Don Cox, MS.

Youssif Al-Nashif, MS

NEW!

National Science Foundation
WHERE DISCOVERIES BEGIN

[Center for Autonomic Computing](www.ece.arizona.edu)

www.ece.arizona.edu

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Introduction

- **Circa 2000 - F-18**
  - **Preflight status awareness**
  - **Tactical view integrated manually**
  - **Update via voice**
  - **Limited data security**
  - **Radar flight following**

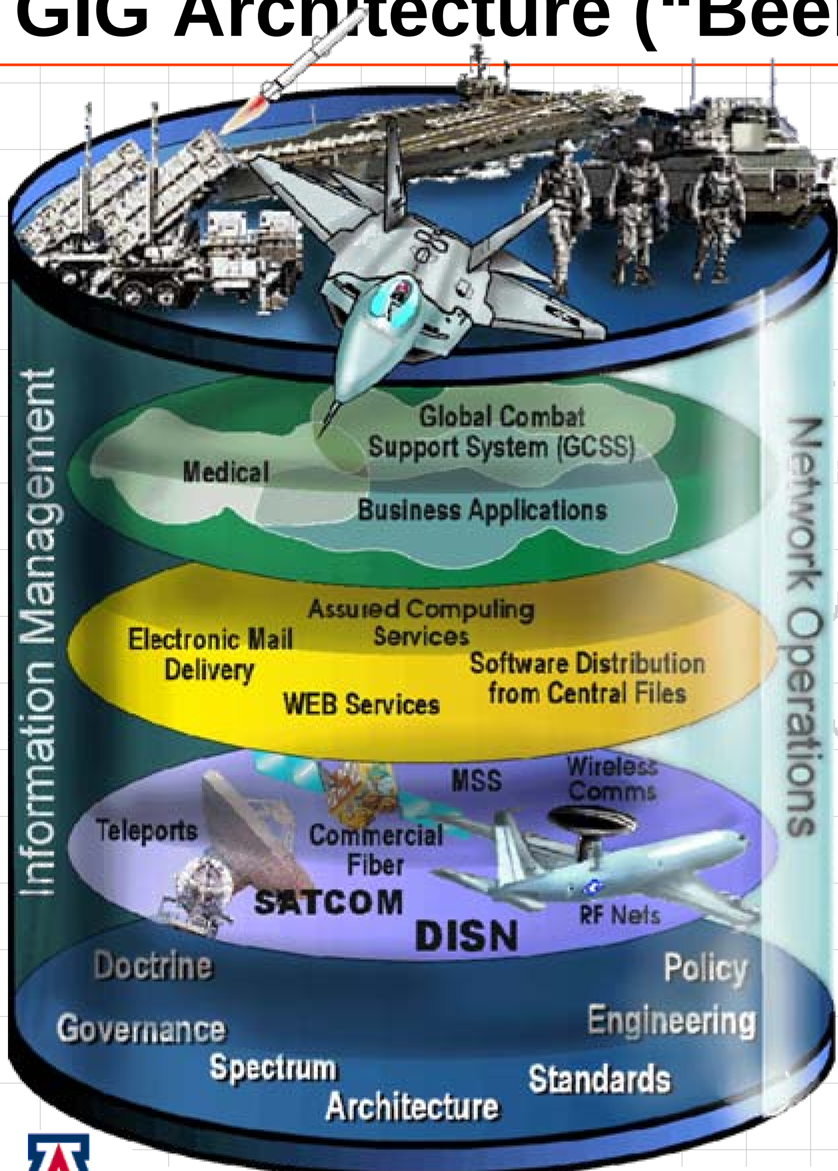
- **Circa 2015 – F-22**
  - **Integrated *Global Information Grid***
  - **Real-time data from forward C^{4}I center**
  - **Dynamic (In-flight) situation updates**
  - **Secure data-link (Intrusion aware)**
  - **C^2 AC mission capability awareness**

Difference? Data & Technology Management

GIG History

- The Clinger-Cohen Act, 1996
  - **Information Technology Management Reform Act**
- DoDCIO Memorandum “Global Information Grid,” (9/99)
  - **Version 1.0 Approved by DoD CIO -- 8/01**
  - **Version 2.0 Approval by DoD CIO -- 8/03**
- DoD Directive Number 8100.1 (11/03)
  - **Global Information Grid (GIG) Overarching Policy**

GIG Architecture ("Beer Barrel")



Warfighters (Joint Services)

Common set of information capabilities
- GIG Enterprise Services (GES)
- Core Enterprise Services (CES)
- Communities-of-Interest (COI)
- Service Oriented Architecture (SOA)

IT Infrastructure

DoD Foundation
- Policy/Doctrine/Governance
- Standards/Engineering/Architecture

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Net Centric Aircraft?

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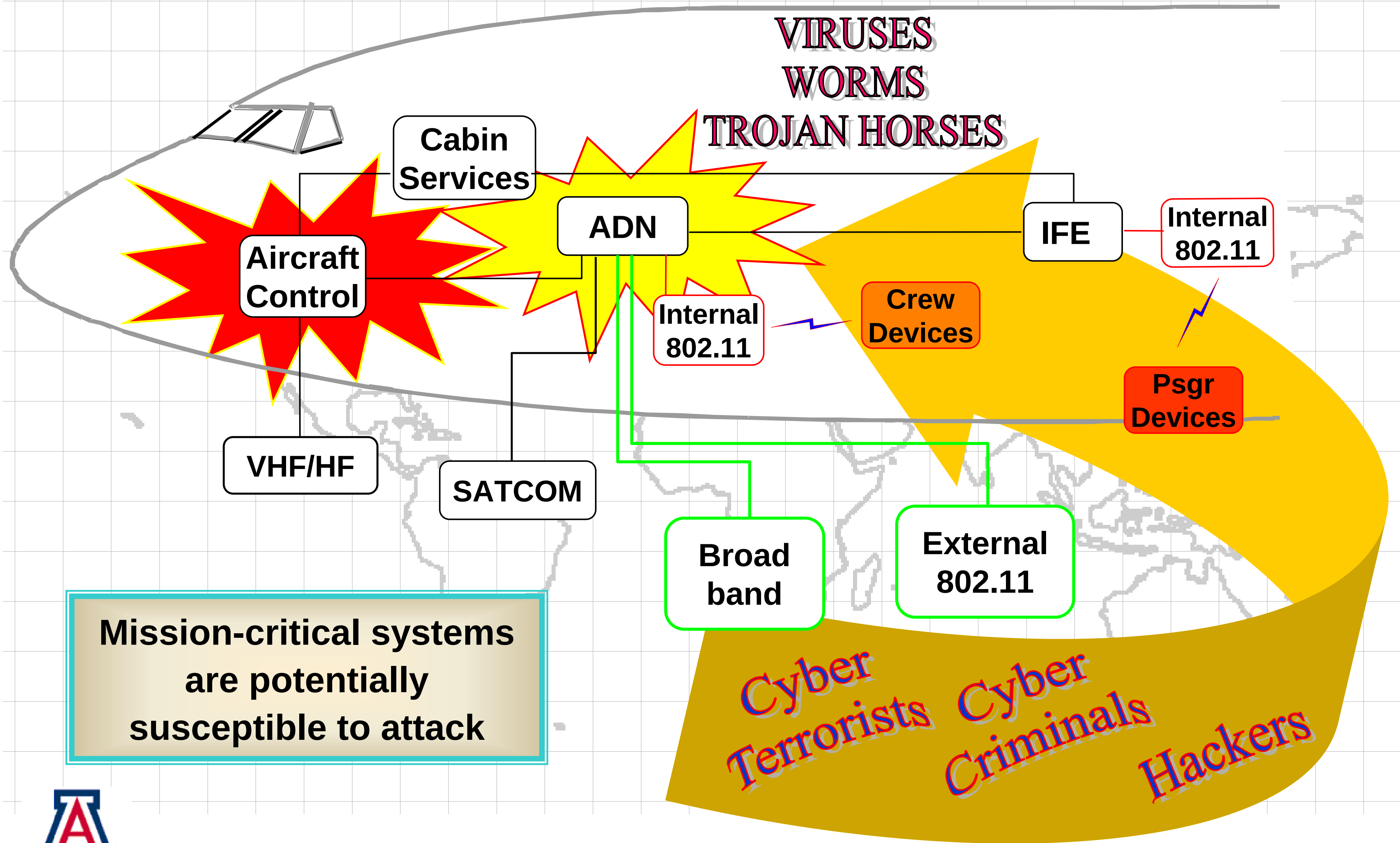
GIG Security Challenges



Mission-critical systems are potentially susceptible to attack

Autonomic Computing

Self-Protecting — **Detect internal/external attacks and protect it's resources from exploitation.**

Self-Optimizing — **Detect sub-optimal behaviors and intelligently optimize resource performance.**

Self-Healing — **Detect hardware/software failures and reconfigure to permit continued operations.**

Self-Configuring — **Dynamically change resource configuration to maintain system & application requirements.**

***Autonomia* will ultimately provide all necessary tools for control and management of GIG networks and services.**

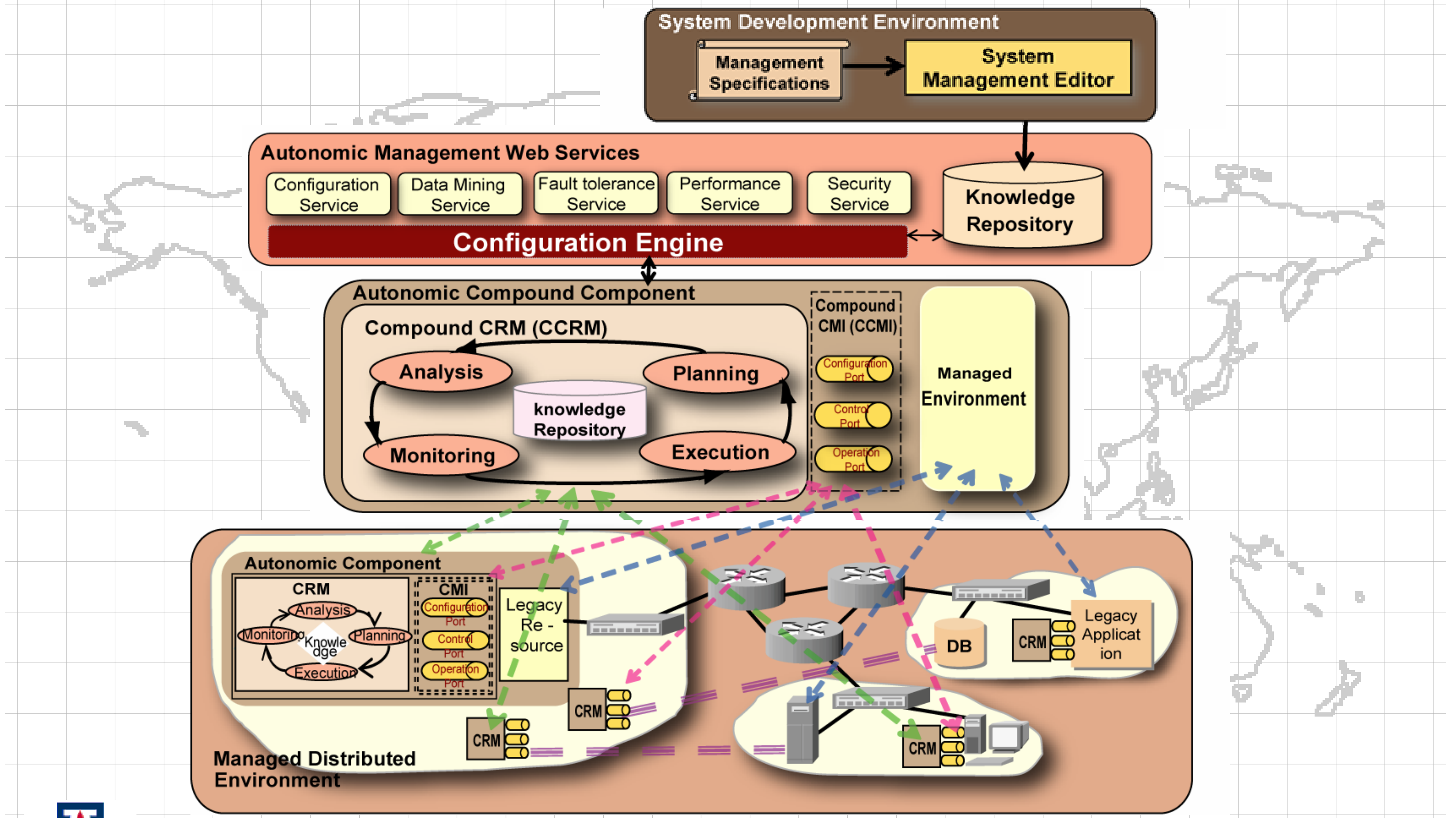
Autonomia Classification

- **Policy rule - Condition-action policy dictates the actions that should be taken whenever the system is in a given state.**

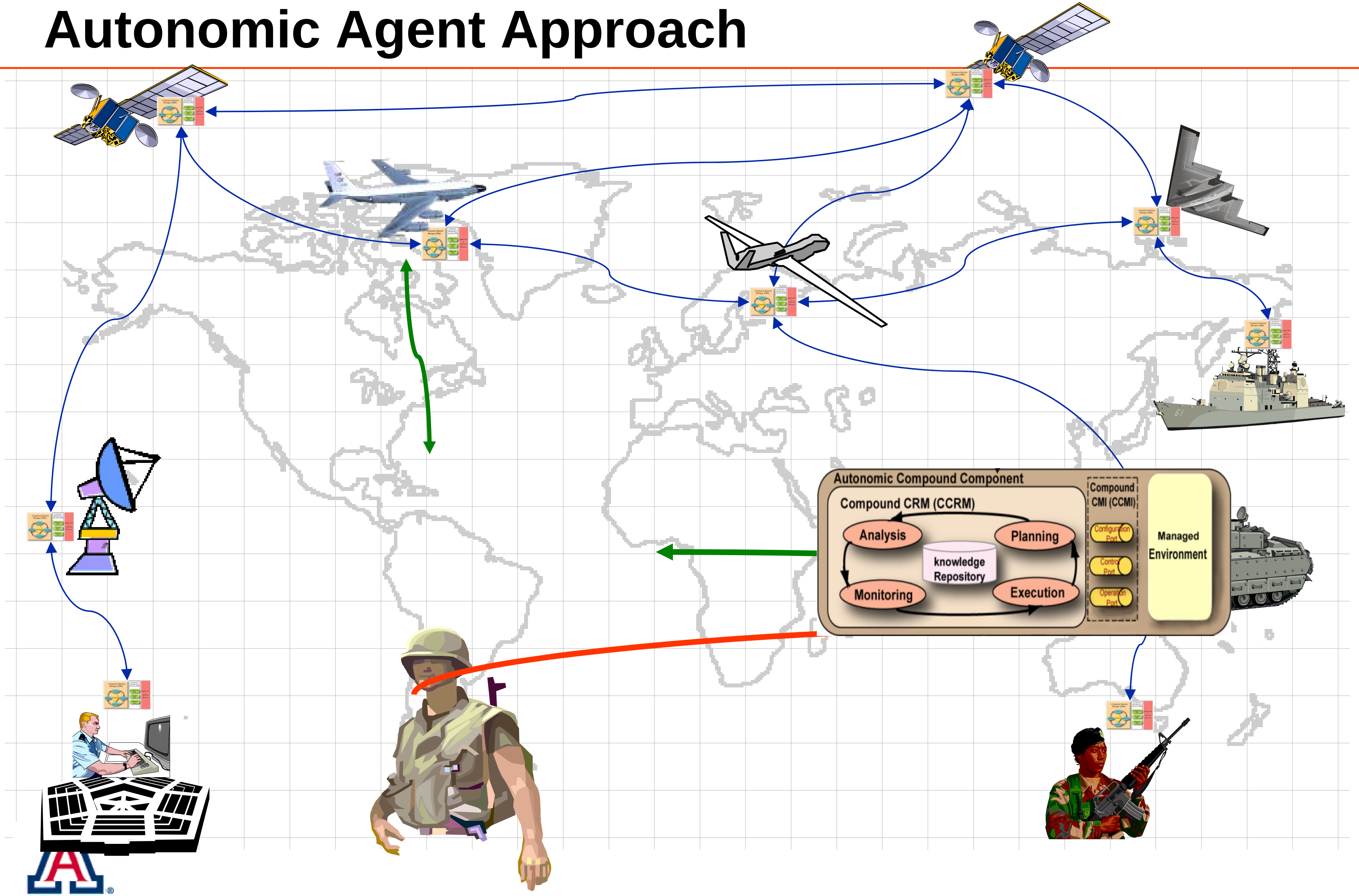
- **Optimization - Analytical techniques are used to model the overall system behavior and services through a utility function that is used to select the optimal adaptation strategy.**

- **Artificial Intelligence - AI planning & learning techniques model system behavior by using data mining and statistical techniques.**

Autonomia Architecture



Autonomic Agent Approach



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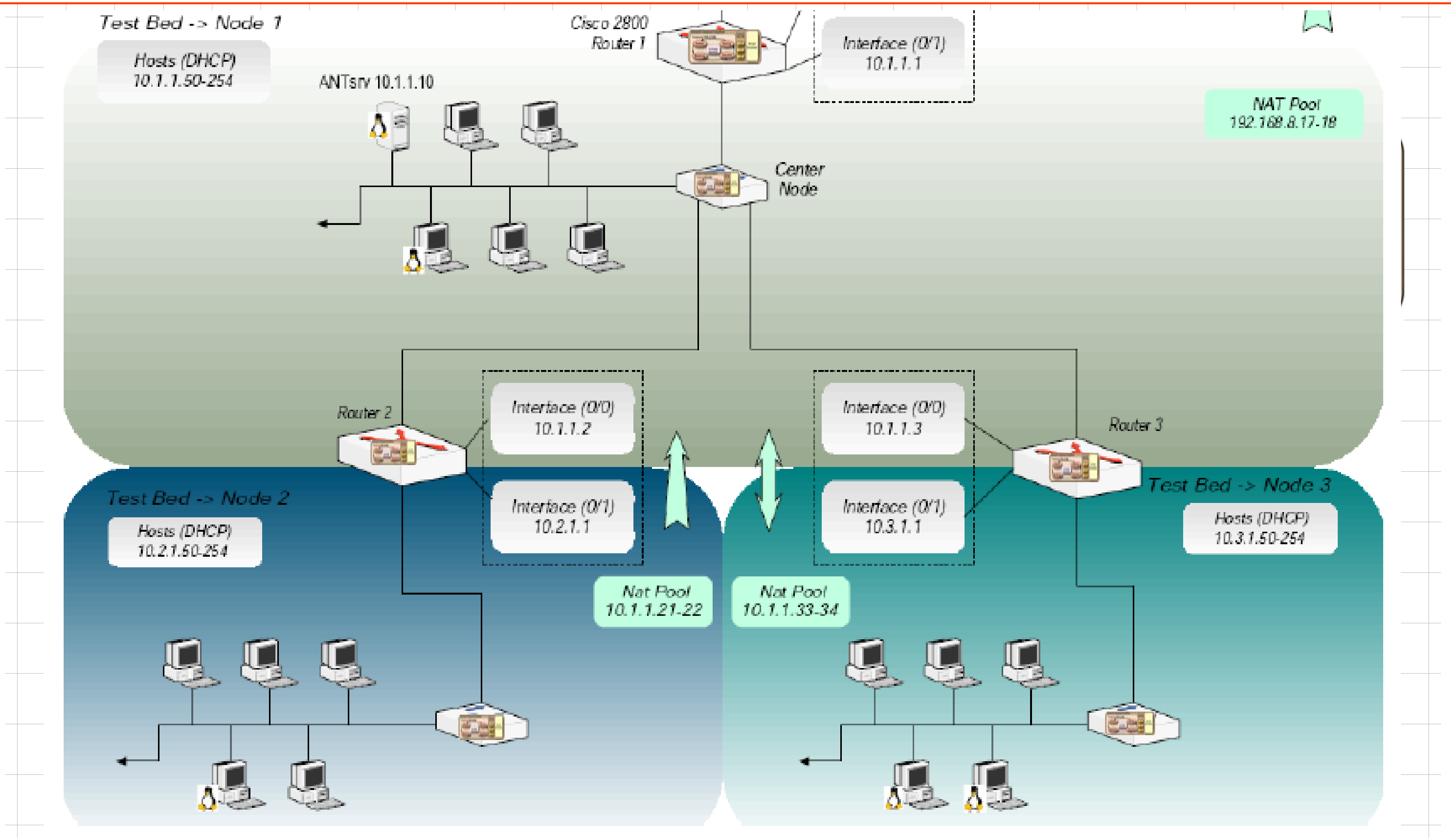
Autonomia Testbed



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Test Results

USAF testing of Autonomia (Detection)

290,870 Netflow records – (70K normal + 220K abnormal)

Attack Category	*Attack Methods*	*Results*
Scanning	Xprobe2, APNET, Nikto, Traceroute, Nessus, SARA, NMAP , Queso	Detected
	Whisker, enum	Not detected
Passive Scanning	Ettercap	Not detected
Exploits	Ownstation, Snooqer, SMB/RPC Nuke, Jolt2, RPC DCOM, Octopus, Killthemessenger	Not detected
R2L	Netcat	Detected
DoS Attack	TCP SYN Flooding Attack, UDP flooding, ICMP flooding	Detected
Worm	theodin worm	Detected

False Alarms: 3

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Feature Selection Validation

- USAF LAN (capture)
  - DARPA Dataset KDD99 (Lincoln Labs)
  - 9 Weeks raw TCP dump data.
  - 5M connection records + 49K training records
  - 41 features
  - 22 different attack types

Class	UA Approach	Winner Entry using C5.0	CTree
Normal	98.45%	99.5%	92.78%
Dos	99.93%	97.1%	98.91%
U2R	92.55%	13.2%	88.13%
R2L	92.46%	8.4%	7.41%
PROBE	99.91%	83.3%	50.35%

Conclusions

- Autonomia framework - autonomic computing systems and applications
- Supports “design-in” or legacy resources and software systems
- Initial Autonomia software modules to focus on self-protection (minimal)
- Existing Experimental Testbed (University of Arizona, Tucson)
- Effective in detecting and protecting the networks but immature
- Wide range of network attacks
- High detection rate accuracy + very low false alarms
- **Limits:**
  – Could not detect attacks that require payload monitoring or analysis
  – Internal or insider attacks (network monitors or ‘bad eggs’)

QUESTIONS?

Back-up Slides

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Network Attack Technology

- **Viruses:** Computer program which distributes copies of itself without permission or knowledge of the user.

- **Worms:** Viruses that reproduce and run independently, and travel across network connections.

- **Trojans:** Impostor files that claim to be something desirable but, in fact, are malicious.

- Others:
  - "Man in the Middle"
  - Spoofing
  - Protocol (TCP) attacks

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Additional Research

- **Payload monitoring and analysis**
  - **Current focus is on headers only**
- **Insider attack detection & defense**
- **Military MANET self-protect**
  - **Virtual Network Models**
    - **Network topology mapping targets**
      - **"Man-in-middle"**
      - **Spoofing**
- **Anti-tamper (captured weapons & personnel)**

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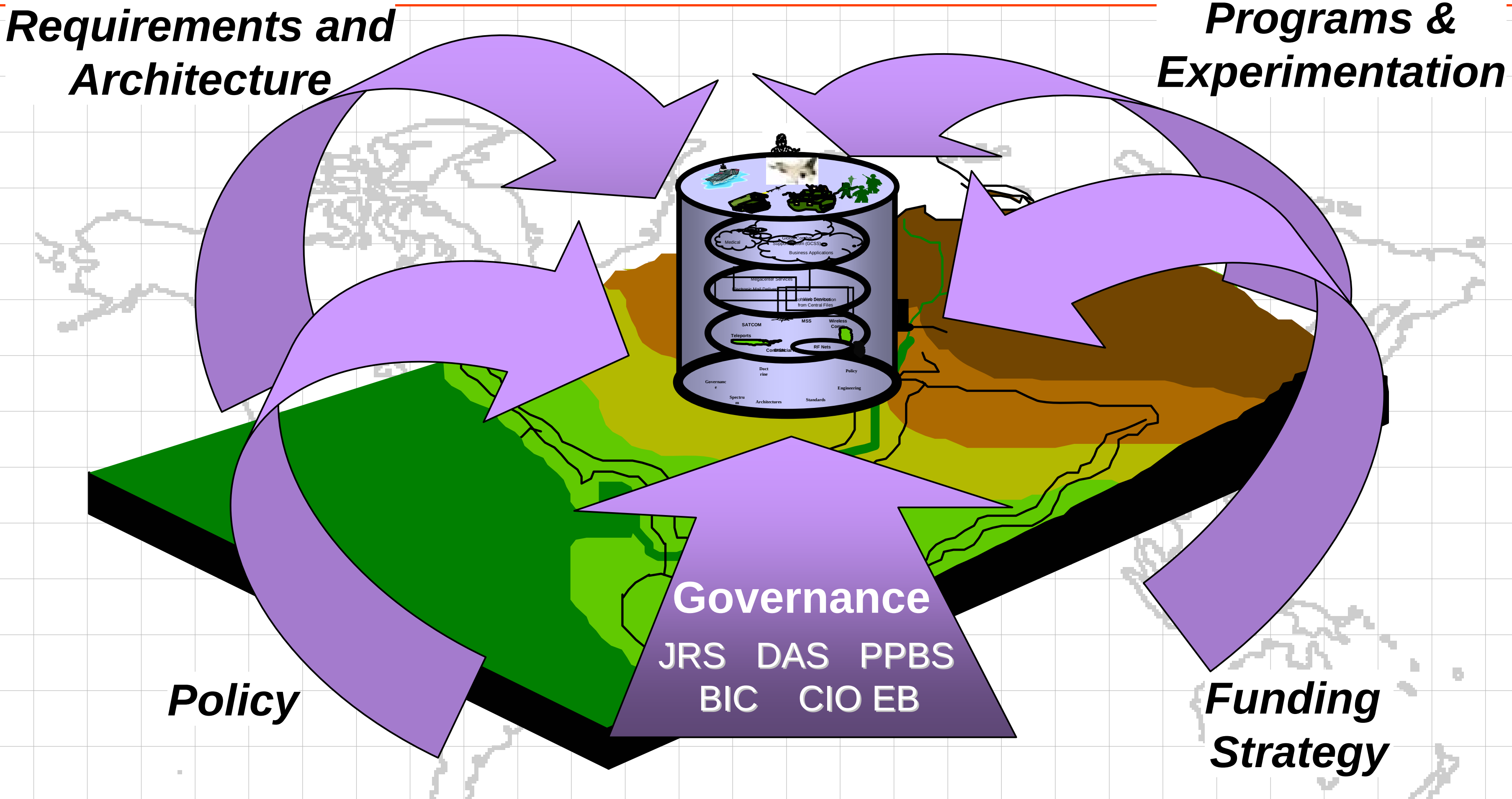
GIG SCOPE



“Develop, maintain and facilitate the implementation of **a sound and integrated information technology architecture** for the executive agency.”

(40 U.S.C. Section 1425)

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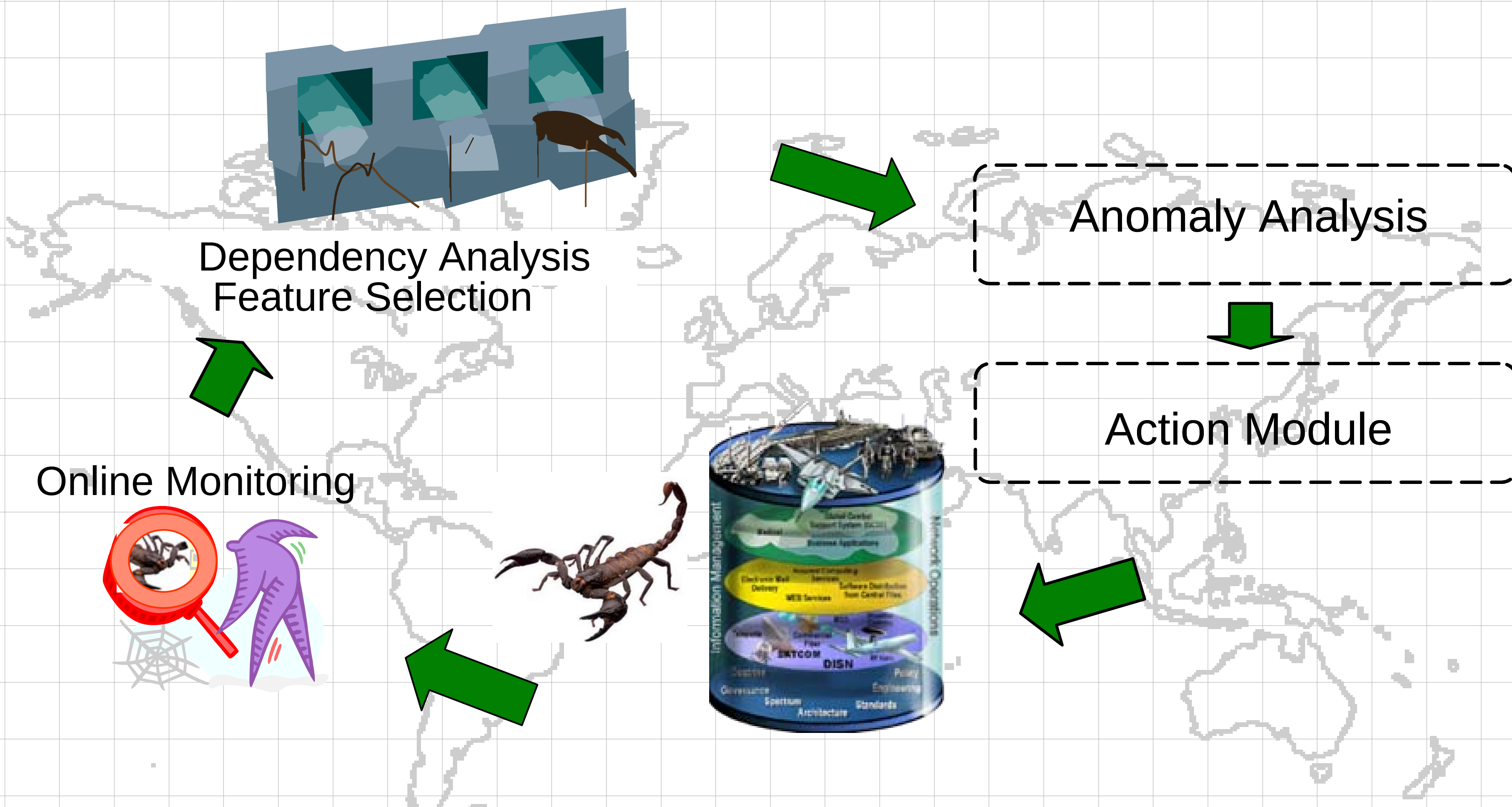
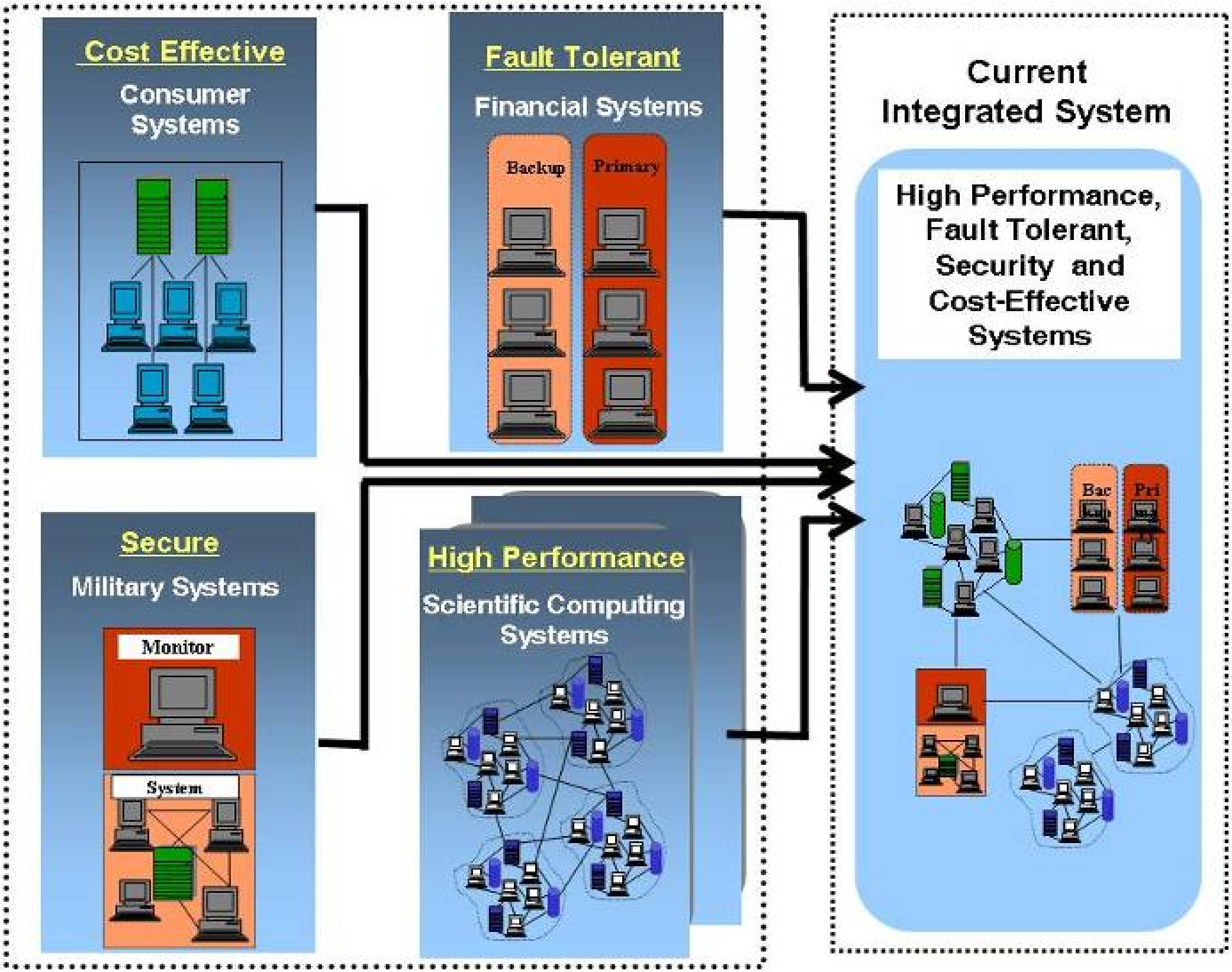
Self-Protection Engine



Primary goals: 1) Detect network attacks, known or unknown,
2) Proactively prevent or minimize impact on network operations and services.

Integration of isolated solutions



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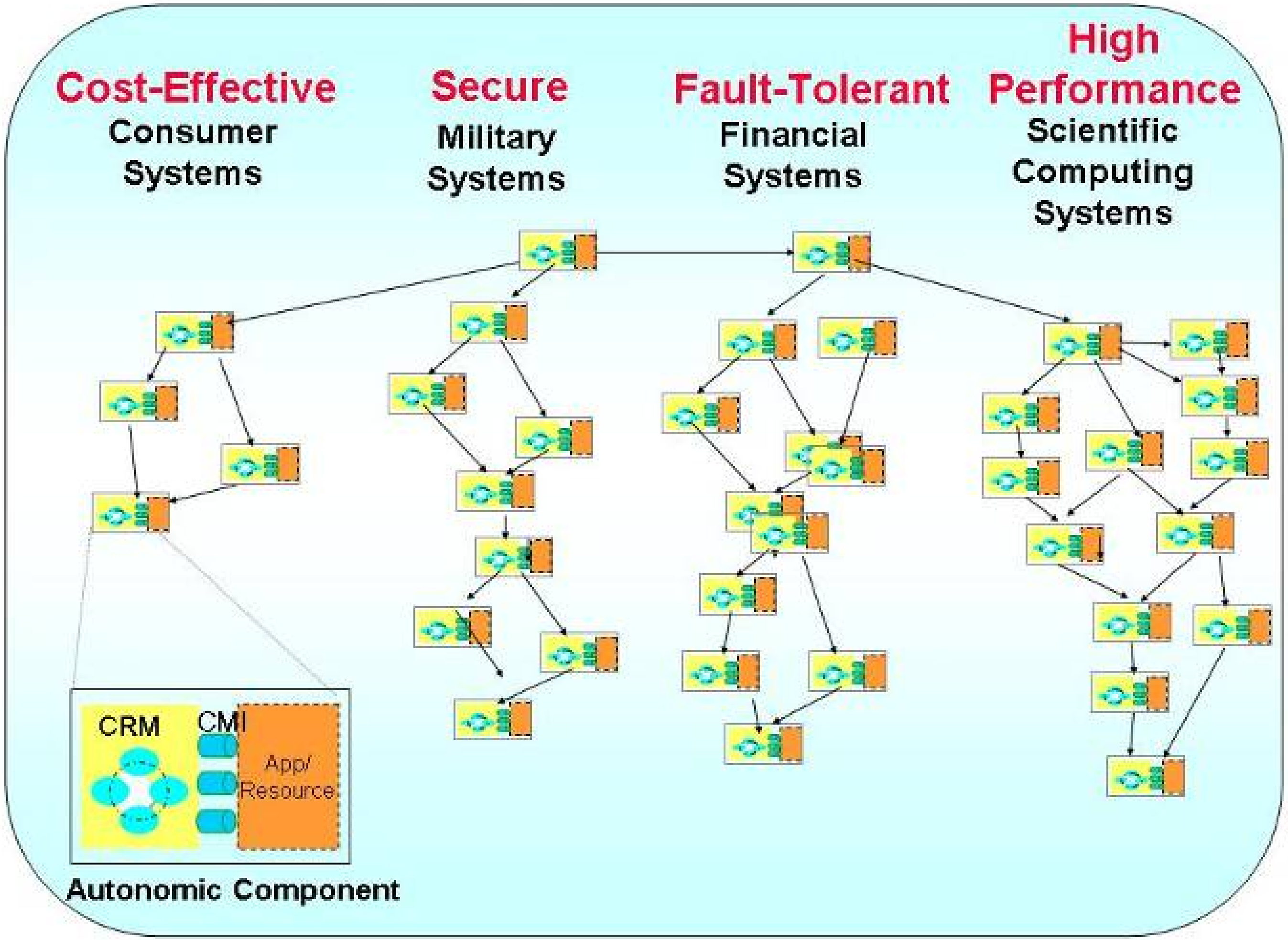
Holistic Approach to Autonomia



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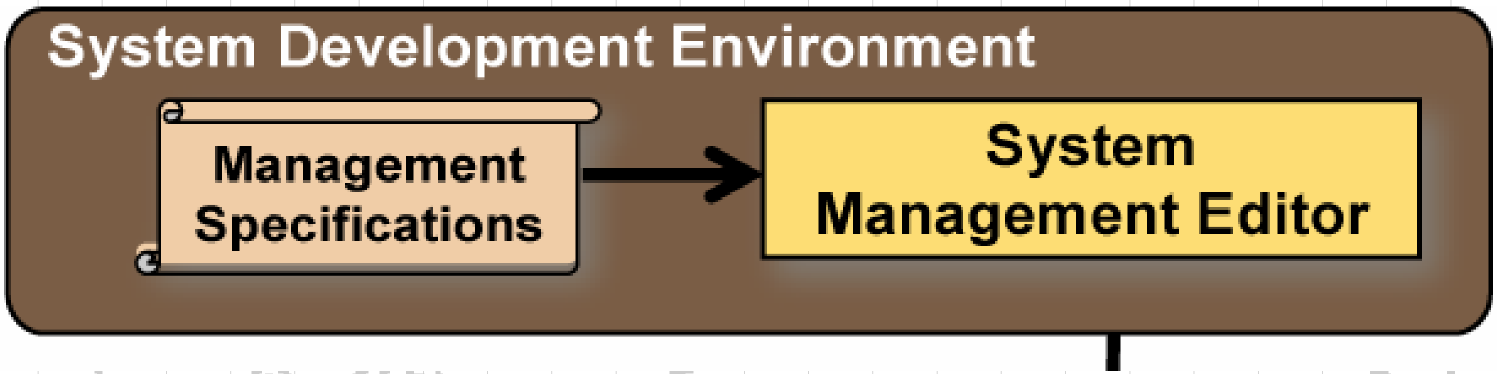
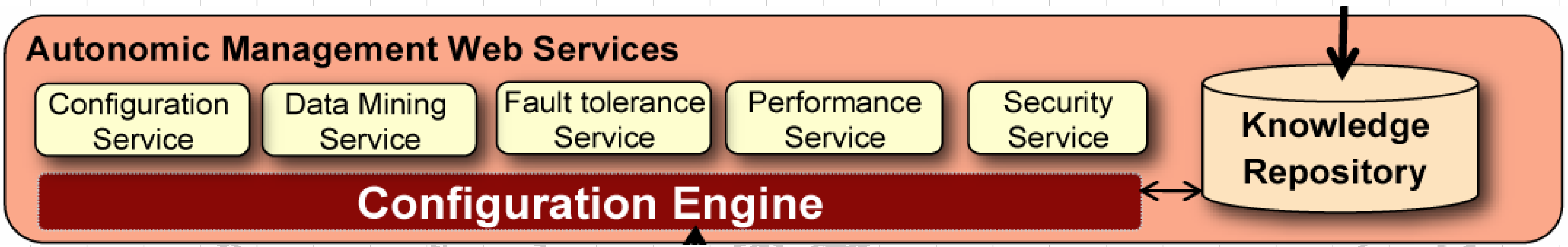
System Management Editor



Publishes component management policies according to the specified CMI schema.

Management Web Services



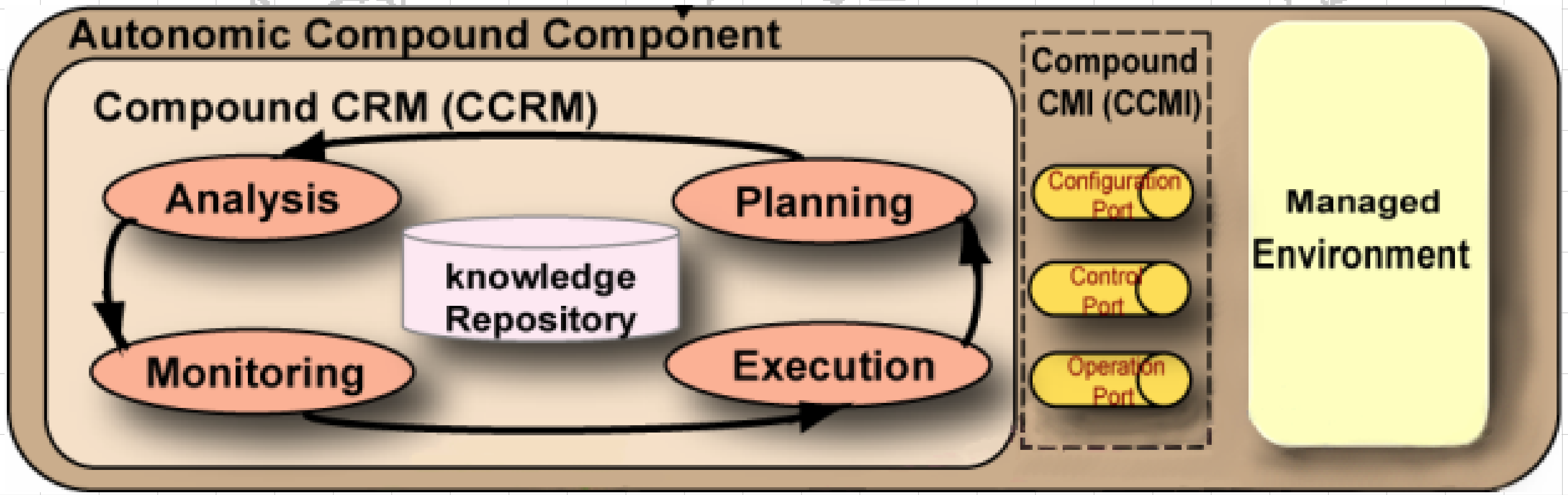
Provides algorithms & run time routines

- –Configuration services
- –Security
- –Fault tolerance
- –Performance

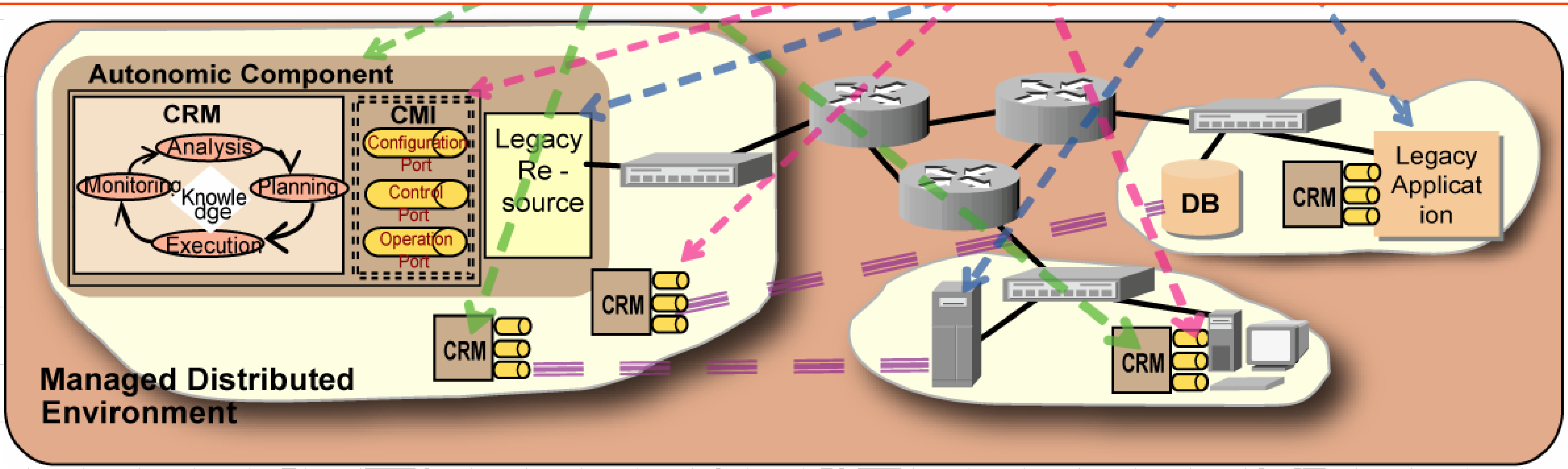
Compound CRM (CCRM)

- **Manages Compound Components**
  - Analysis
  - Monitoring
  - Planning
  - Execution

- **CCMI Ports**
  1. Configuration
  2. Control
  3. Operation

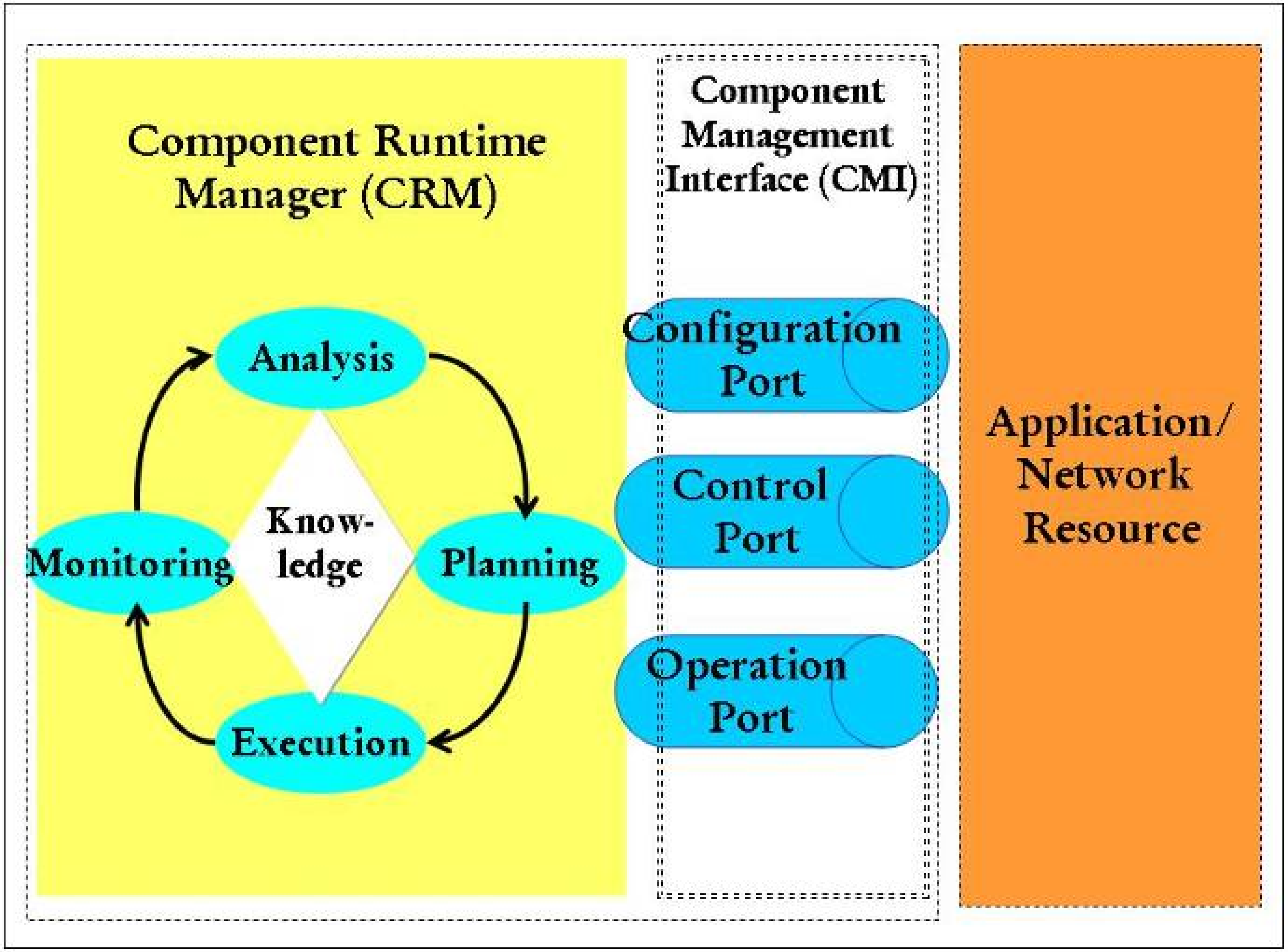


Managed GIG Environment



- **Larger autonomic systems**
  - **Hierarchical manner**
  - **Composed of many autonomic compound components**
  - **Deployed dynamically**
  - **Once deployed, becomes self-maintaining ("living")**

CRM/CMI



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NetFlow Data

Variable	Definition
Hid	Sequence id
Bytes	Number of bytes in this interval for a connection
Pkts	Number of packets in this interval for a connection
Input_snmp	related incoming/outgoing interface information
Output_snmp	
src_addr	IP source and destination address information
dst_addr	
Prot	Protocol number
L4_src/dst_port	Layer 4 port information
Next_hop	Next hop information
Src/dst_AS	Srouce/destination AS
Src/dst_mask	Mask of the src/dst IP
Tcp_flags	Bitwise OR of tcp flags
Src_tos	TOS of the connection

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Feature Selection

FEATURE X	I(X; DOS)	I(X;DOS) / H(DOS)
count	0.647571	0.899405
dst_bytes	0.512438	0.711719
dst_host_same_src_port_rate	0.382541	0.531308
srv_count	0.338744	0.470478
dst_host_count	0.308133	0.427963
src_bytes	0.290684	0.403728
dst_host_srv_diff_host_rate	0.274275	0.380937
dst_host_srv_count	0.165472	0.229823
srv_diff_host_rate	0.165142	0.229364
dst_host_same_srv_rate	0.149499	0.207638
dst_host_diff_srv_rate	0.14109	0.195959
diff_srv_rate	0.084967	0.118009
dst_host_srv_serror_rate	0.081939	0.113804
same_srv_rate	0.080769	0.112179
dst_host_serror_rate	0.076816	0.106688

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(End Presentation)

Integrated Risk and Earned Value Management

2007 NDIA Systems Engineering Conference
San Diego, CA

October 24, 2007

Paul Davis
Northrop Grumman Corporation

Contents

Uncertainty Management Premises

- **A failure to meet project objectives is a failure in uncertainty management**
- **Uncertainty management**
  - Risk management (RM) – minimizing negative consequences
  - Opportunity management – maximizing positive consequences
- **Risk management = Uncertainty management**
- **Uncertainty management**
  - Affects project execution
  - Changes the project future by
    - Identifying uncertainty
    - Measuring uncertainty
      - Risk exposure (likelihood X impact)
    - Improving effective of uncertainty handling
    - Improving decision making to successfully achieve objectives
- **Improved decision making a key focus**

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State of Industry

- **NDIA - Program Management Systems Committee Survey***
  - RM and EVM integration
  - Oct 2003 to Jun 2004
  - 121 respondents
- **Study findings:**
  - RM and EVM have separate process owners 76% of the time
    - System engineering
    - Program management
    - Project control
    - Business/financial management
  - Risk management seldom predicts near-term issues
  - Majority (70%) strongly believes in the value of integrated RM and EVM even though only 34% said they were successfully integrating them

> "Failure to integrate RM, cost-risk analysis, and EVM contributes to overruns. The program manager is denied clear visibility of quantitative RM that could increase the probability of mission success."
>
> **Peter Teets, former Under Secretary of the Air Force**

*** "Integrating Risk Management with Earned Value Management", at www.ndia.org/Content/ContentGroups/Divisions1/Procurement/**

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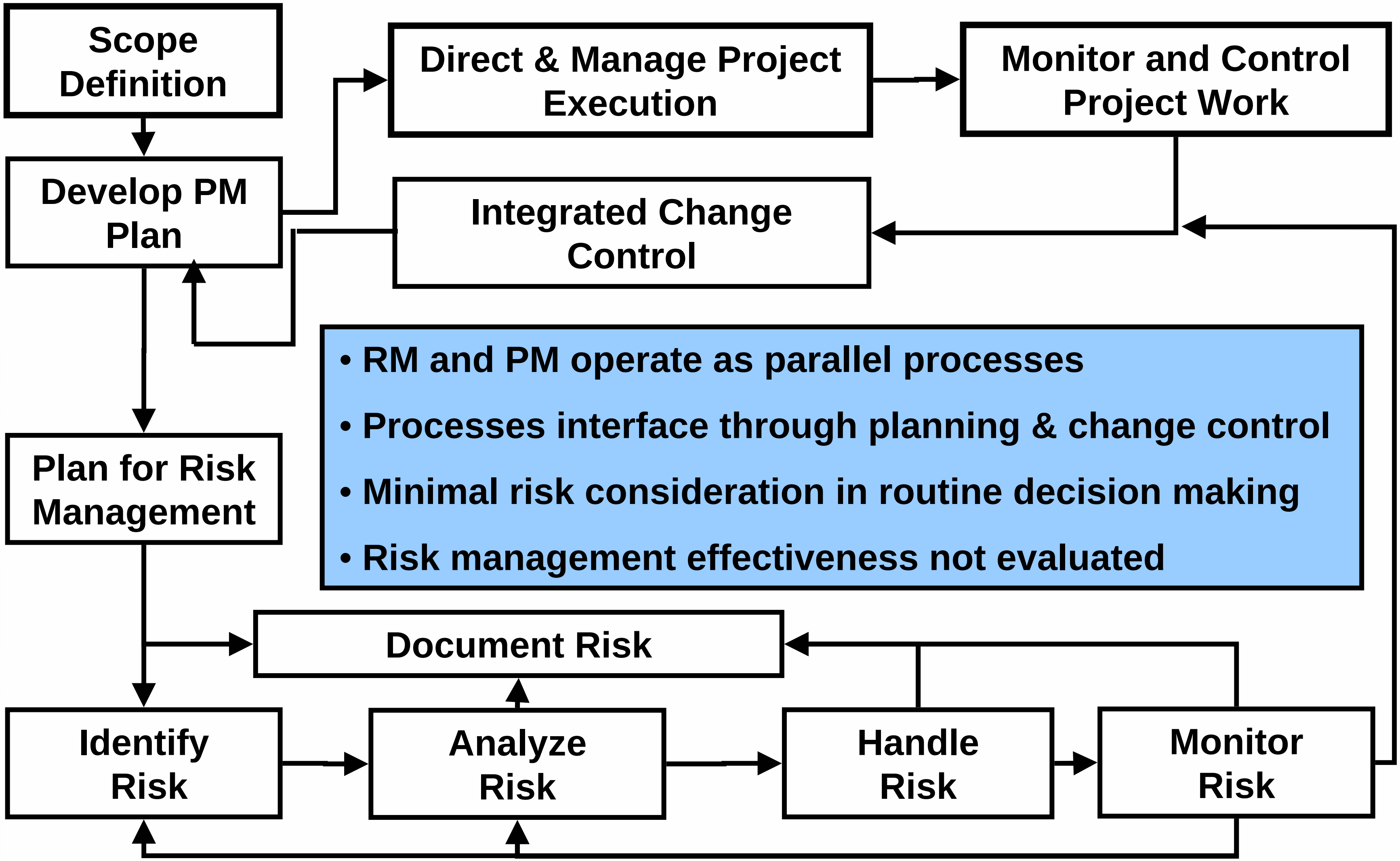
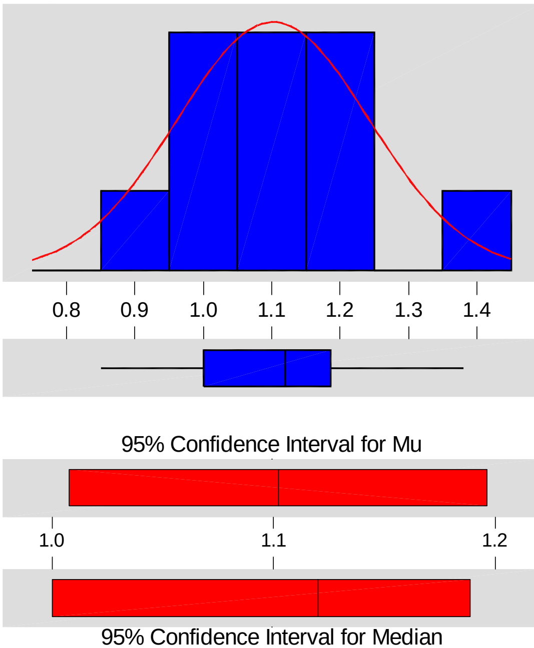
Typical "As-Is" Risk Management



- RM and PM operate as parallel processes
- Processes interface through planning & change control
- Minimal risk consideration in routine decision making
- Risk management effectiveness not evaluated

"As-Is" Risk Management Process Capability – Cost Control

Past Performance Contract References



Variable: CPI Inverse

Anderson-Darling Normality Test

A-Squared:	0.252
P-Value:	0.664
Mean	1.10210
StDev	0.14044
Variance	1.97E-02
Skewness	0.206006
Kurtosis	0.821268
N	11
Minimum	0.85000
1st Quartile	1.00000
Median	1.12000
3rd Quartile	1.18600
Maximum	1.38000

95% Confidence Interval for Mu

1.00776 1.19645

95% Confidence Interval for Sigma

0.09813 0.24646

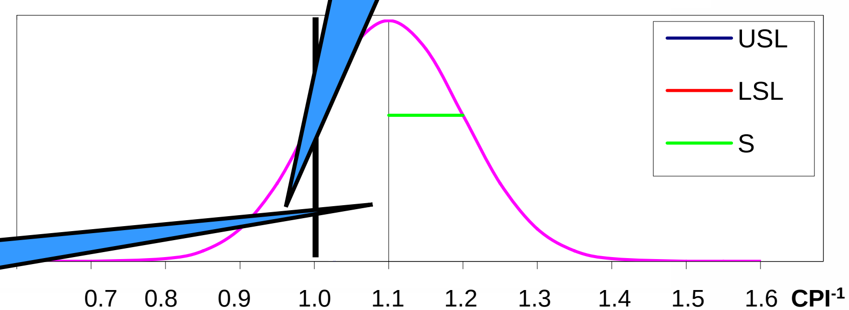
95% Confidence Interval for Median

1.00000 1.18880

Less than 25% of projects meet budgeted costs

Xbar	1.102
S	0.14
USL	1
LSL	
	0.77 sigma

2. Label a Normal curve
- Average
- Standard deviation
- USL (and shade to LEFT for Area 1)
- LSL (and shade to LEFT for Area 2)



Average costs exceed budgeted costs by 10.7%

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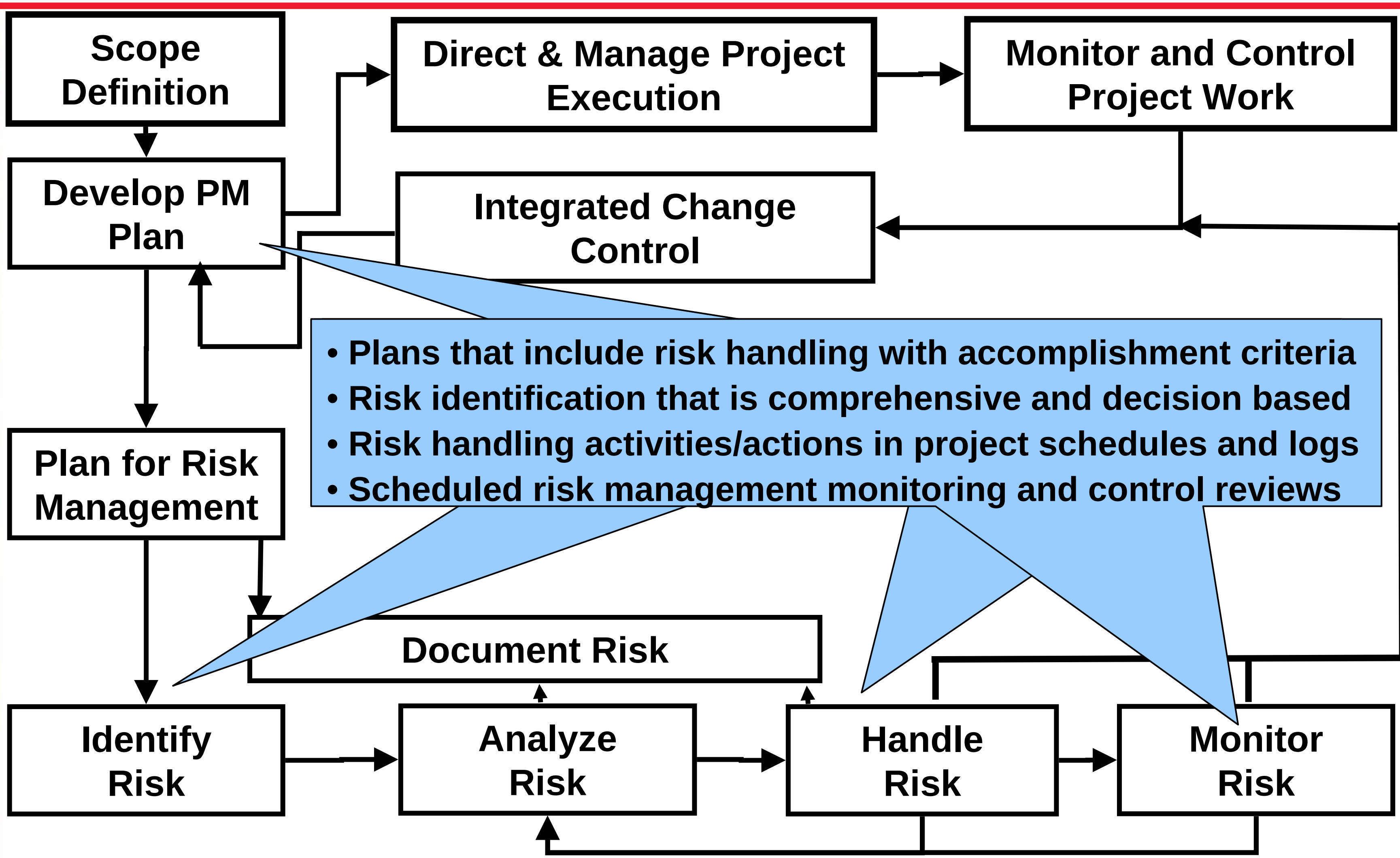
Project Baseline Planning Integrating Risk Management



Effective Risk Management Actions are Comprehensive

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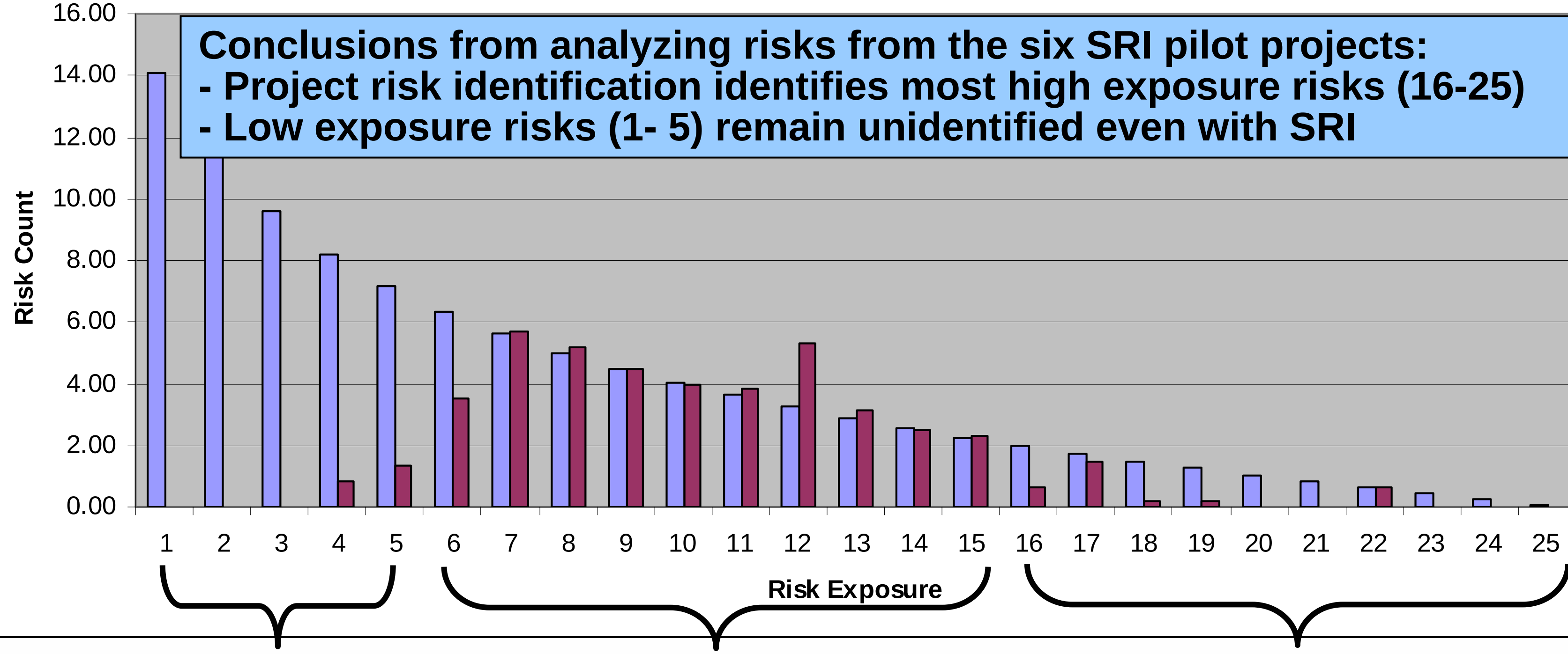
A Structured Risk and Opportunity Identification (SROI) Approach Is Effective in Identifying More Uncertainties

Comparison of risk counts from uniformly distributed risks over a (5 X 5) likelihood-by-impact linear risk space with average counts from 6 SRI pilot projects



Unidentified risks

- **50% of risks**
- **20% of risk exposure**

SRI identified risks

- **42% of risks**
- **55% of risk exposure**

Project-identified risks

- **8% of risks**
- **25% of risk exposure**

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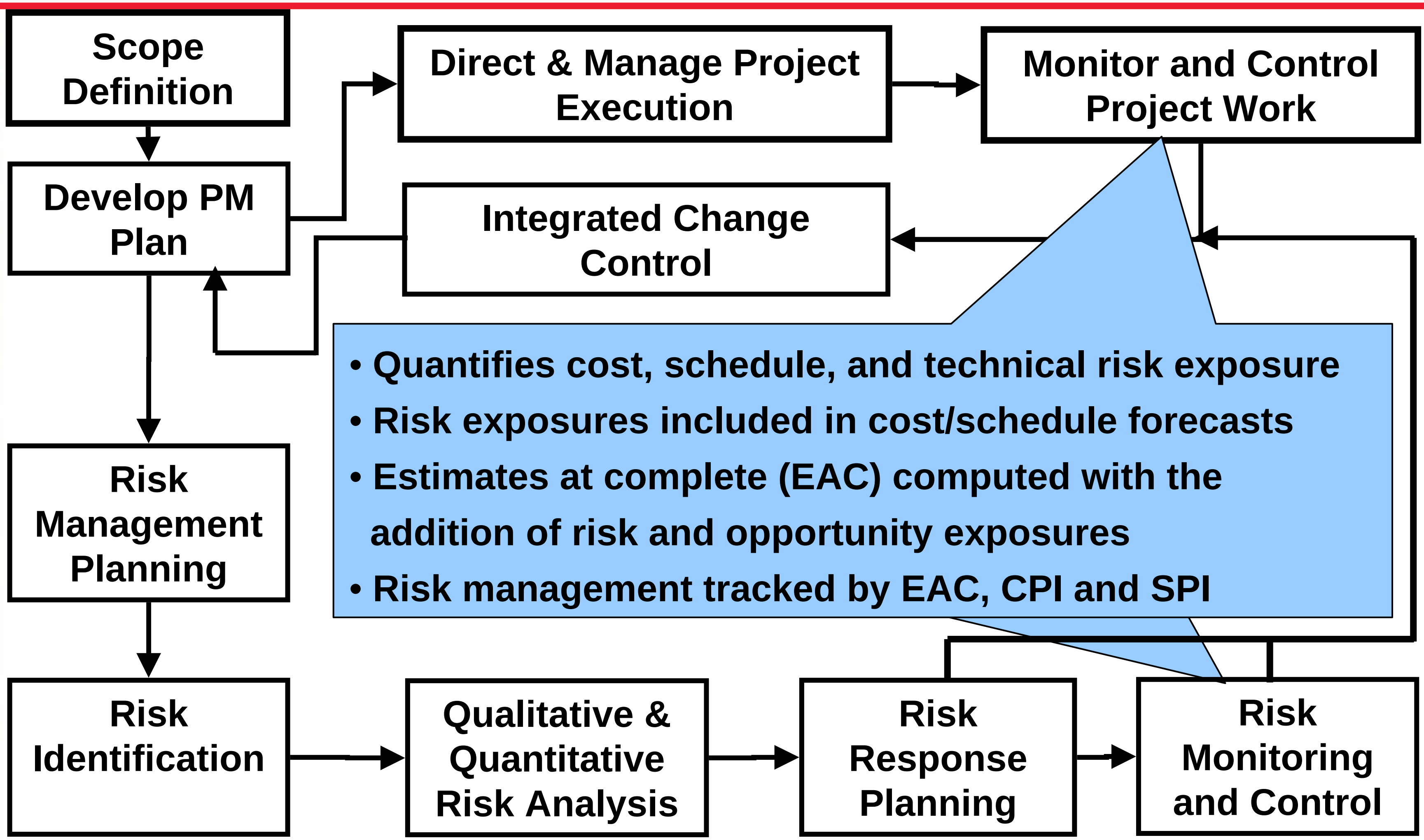
Integrating Risk Monitoring and Control with Project Monitoring and Control



Integrated RM & EVM assists decision making

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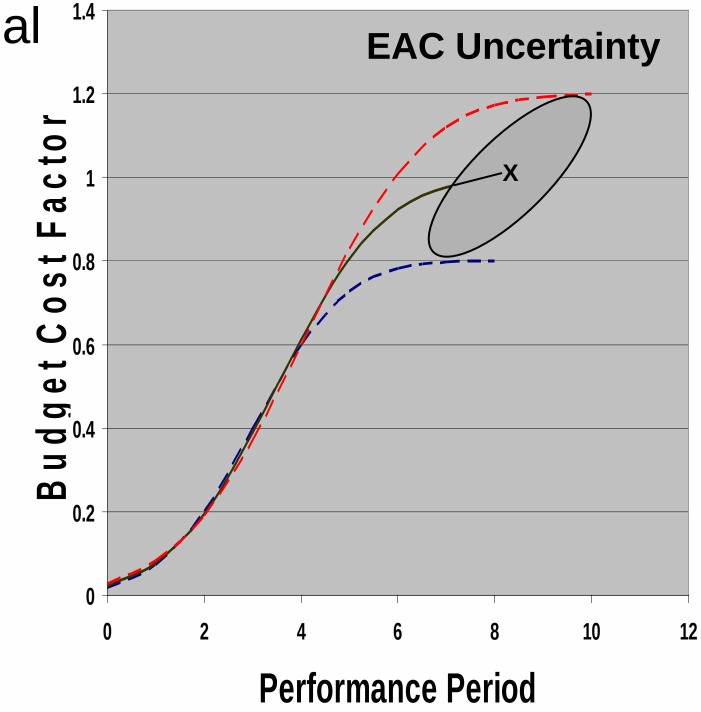
RM and EVM Integration Approaches

- **Barriers to risk management integration***
  - Contractual incentives
  - Technology - tools
  - RM or EVM process maturity
  - Internal/external management cultures
  - Organizational
  - Baseline instability
  - Emotional



- **RM-EVM integration approaches**
  - EAC with and without risk exposure
  - Residual uncertainties in forecasts with statistical profiles and EAC ellipses
  - Risk handling earned value monitoring – residual risks monitored against plans
  - Cost and schedule performance indices (CPI and SPI) monitoring and control
- **Focus on risk handling, not mechanics**

* "Integrating Risk Management with Earned Value Management", NDIA Study Report 2005

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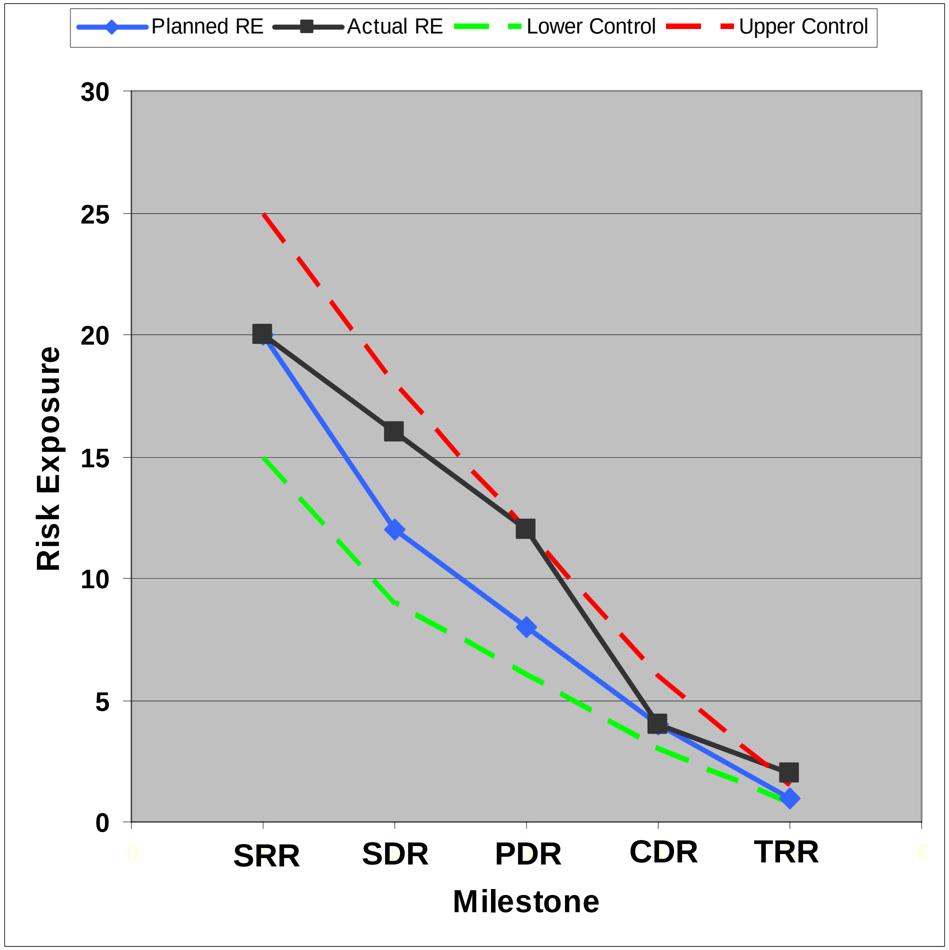
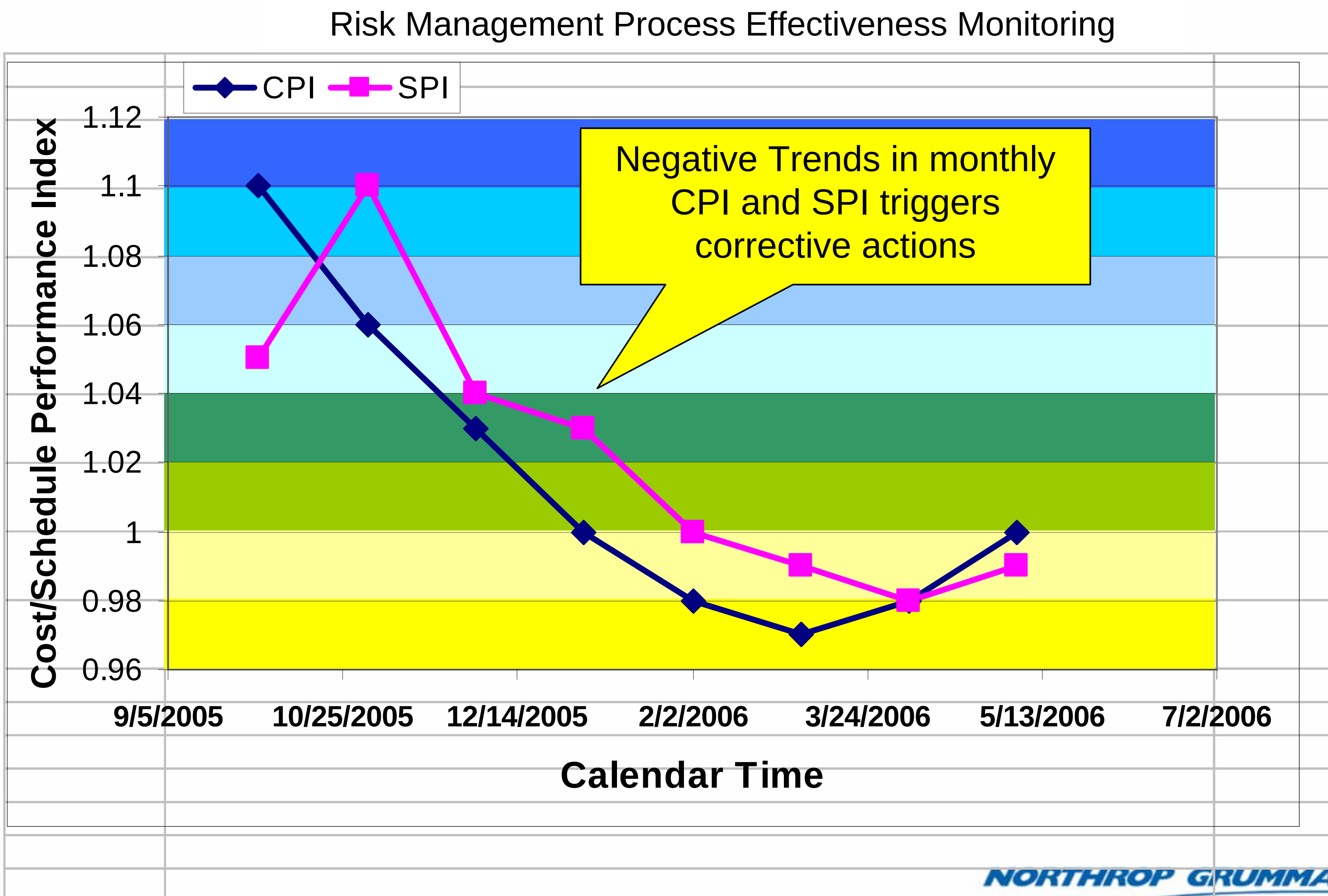
"Earned Value" Monitoring Measures Risk Handling Effectiveness

- **Monitors actual handling performance against plans**
- **Performance-based earned value® measures**
  - A means to measure uncertainty management effectiveness performance
- **Measures <u>effectiveness</u> of uncertainty management, not just task completion**
- **Triggers uncertainty management corrective actions**



® **Performance-Based Earned Value is registered with the U.S. Patent and Trademark Office by Paul Solomon.**

Cost / Schedule Performance Monitoring Provides Leading Indicators for Corrective Action



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Summary

- RM-EVM integration provides leading indicators that increase response time and probability of success
- A structured risk identification approach increases risk assessment comprehension

- Quantified uncertainty metrics are a basis for effective management
- Alternative RM-EVM integration approaches can be selected to meet project needs
- Focus on uncertainty handling and project decision making -- not on uncertainty computation mechanics

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NAVAL
POSTGRDUATE
SCHOOL

Quantitative Comparison of Alternative Designs for a Joint C4I Capability Certification Management (JC3M) System

A Student Project

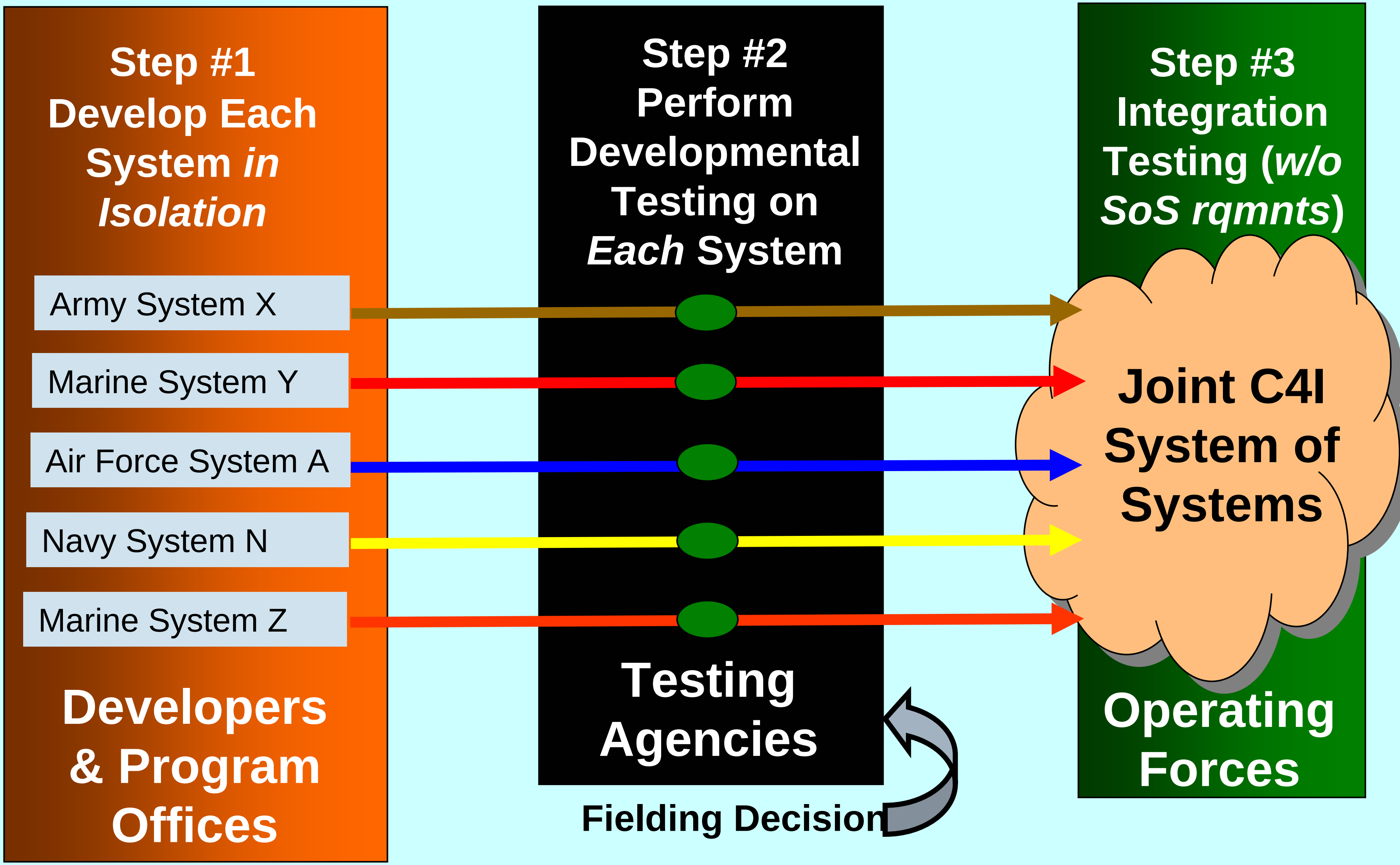
Gregory A. Miller
Naval Postgraduate School
Monterey, CA

Ian Finn
Marine Corps Tactical
Systems Support Activity
Camp Pendleton, CA

Outline

- Introduction & motivation
- A tailored SE process
- Problem refinement
- Design Alternatives
- Modeling & Simulation
- Life Cycle Cost Estimates
- Analysis of Alternatives
- Conclusions and further study

Motivation: Acquisition system & SoS integration needs



Current SoS Testing and Fielding

Step #1
Develop Systems in isolation

Step #2
Perform Developmental Testing on each System

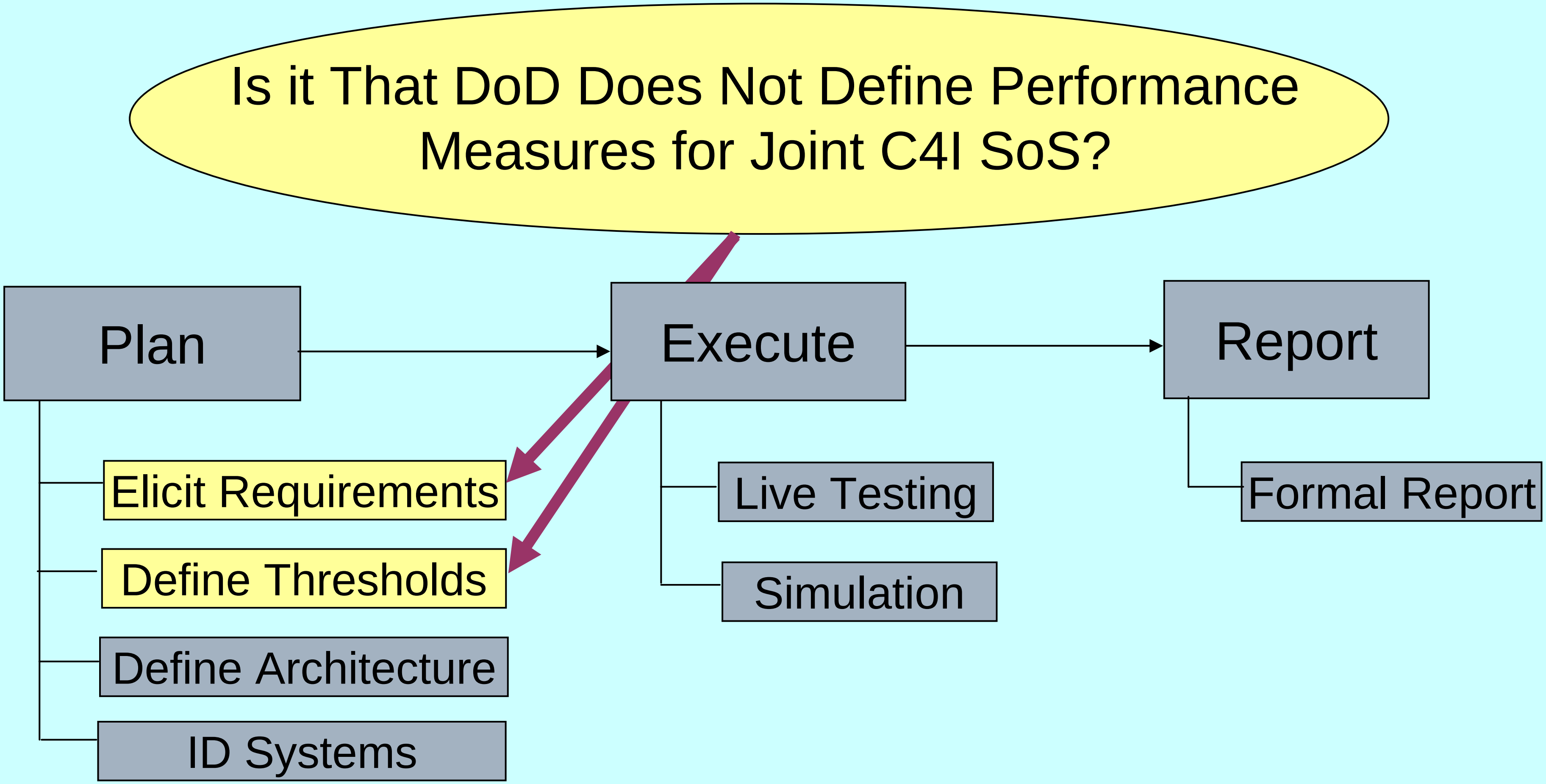
Step #3
Perform System of Systems Testing

Step #4
Field

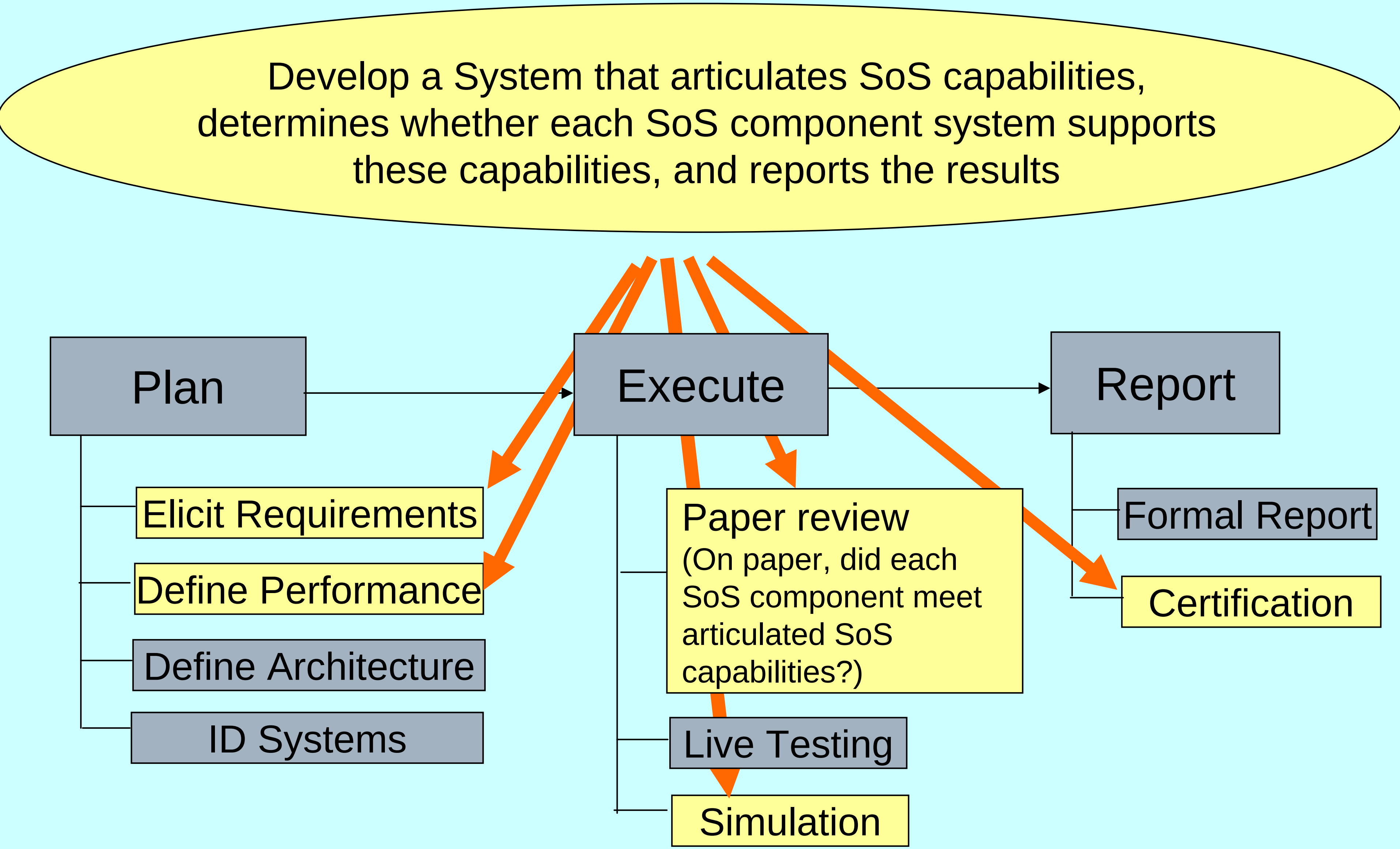
Joint C4I System of Systems

- Problem with SoS Testing
  - No Performance Measurements
  - What Architecture is Appropriate? Joint C4I SoS are Large and Constantly Changing
  - Testing Every SoS Function is Impossible
  - Hard to Determine What Failure is Since Quality of Service Requirements Change

What is the Real Problem?



What's the Solution?



JC3M in Testing and Fielding

(Currently unavoidable)

Step #1

Develop Systems in isolation

(Currently unavoidable)

Step #2

Perform Developmental Testing on each System

(Replaces current SoS testing methodology)

Step #3

Perform JC3M (Plan, Execute, Report)

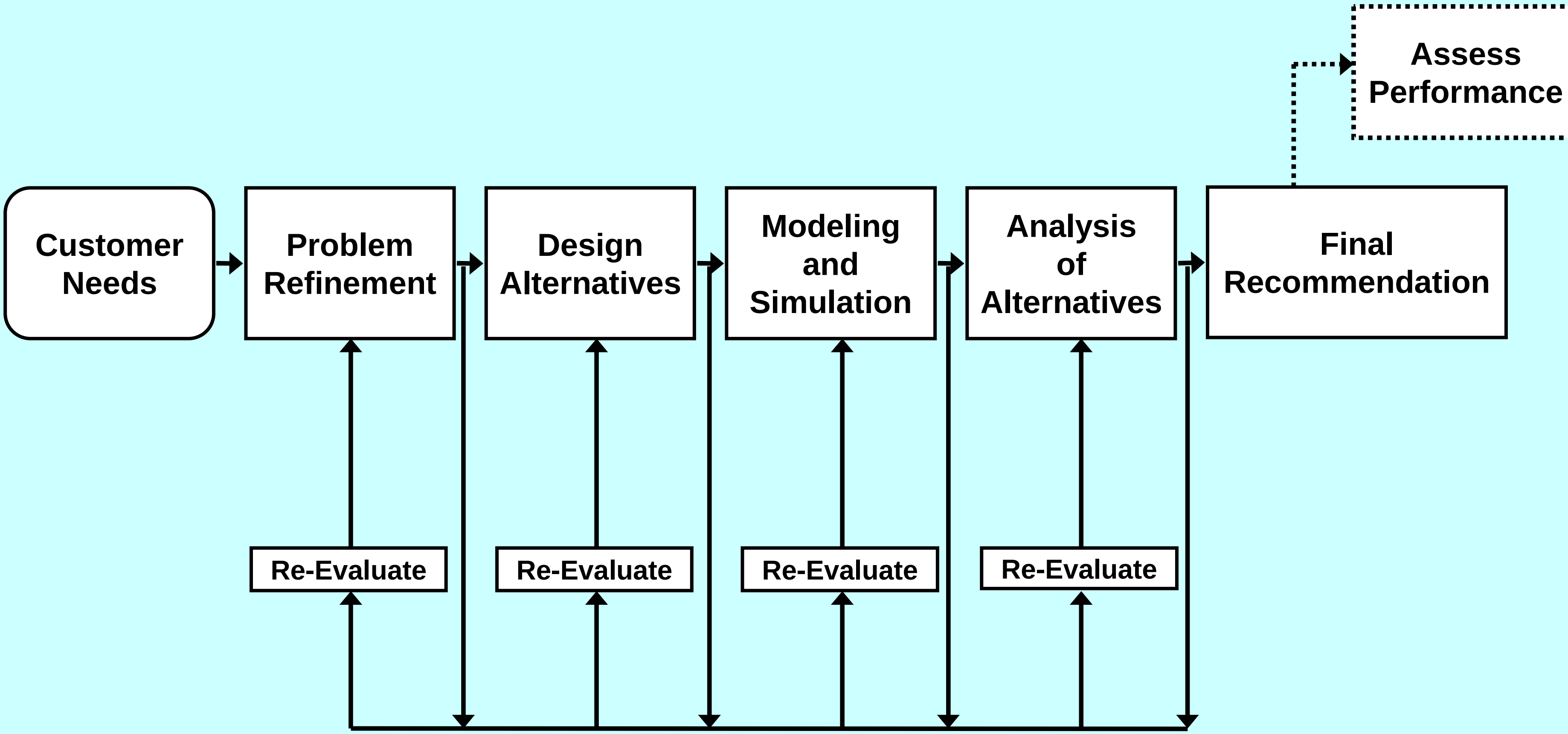
Step #4

Field

Joint C4I System of Systems

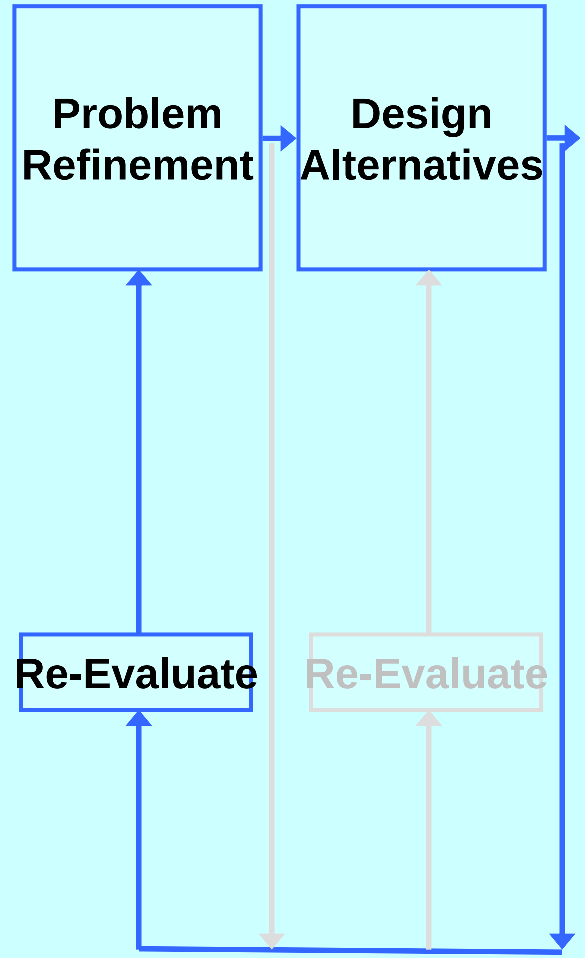
- JC3M goals:
  - *Acquire* objective SoS Performance Measurements for Acquisition and User Communities
  - *Produce* Decision Data for Stakeholders
  - *Provide* confidence in SoS Performance for Users

Systems Engineering Process

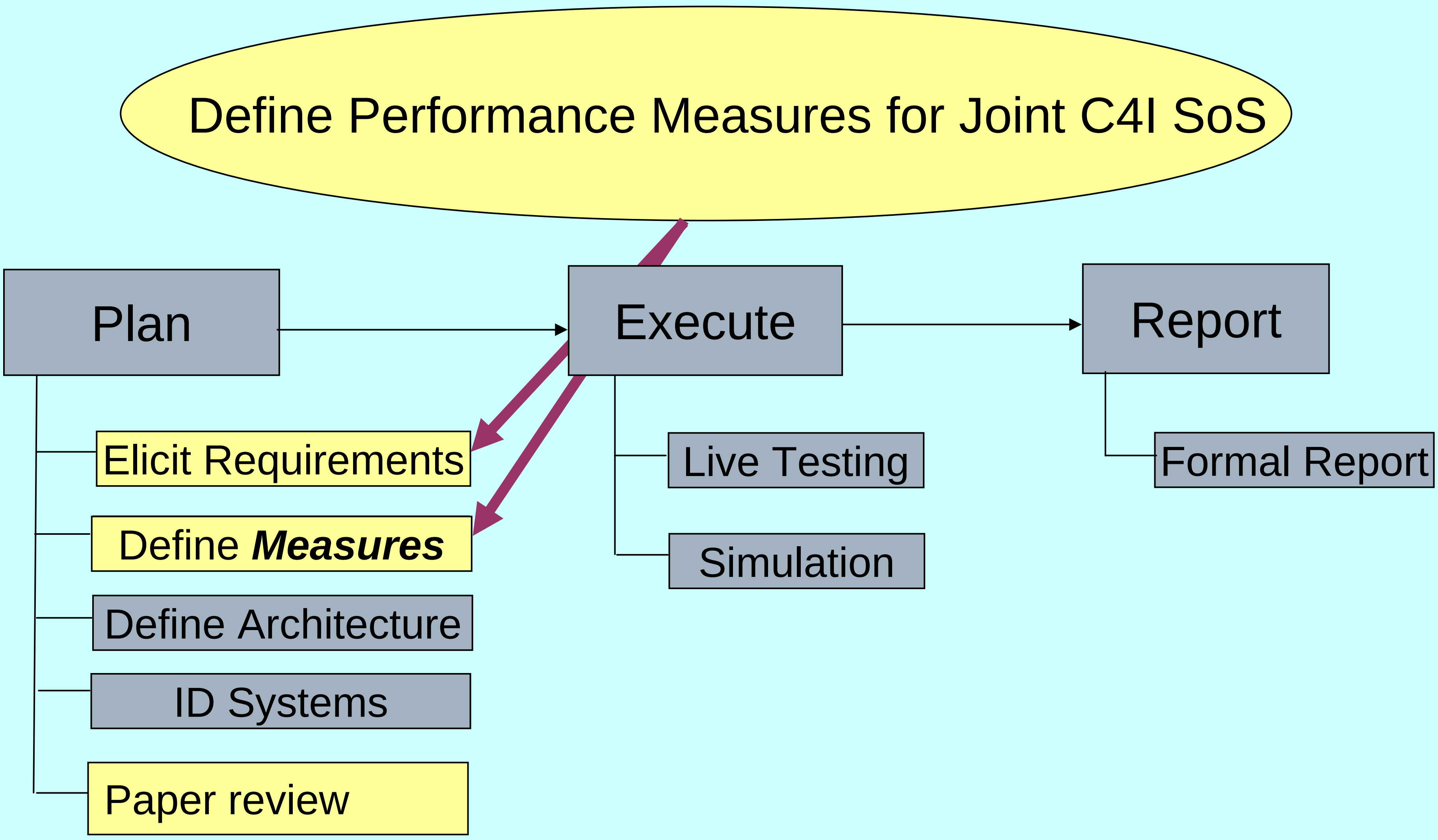


Revised Problem Statement

- Original problem focus:
  - Define Threshold Values
- Research revealed the true problem …
- Refined problem focus:
  - Define Measures to be Evaluated

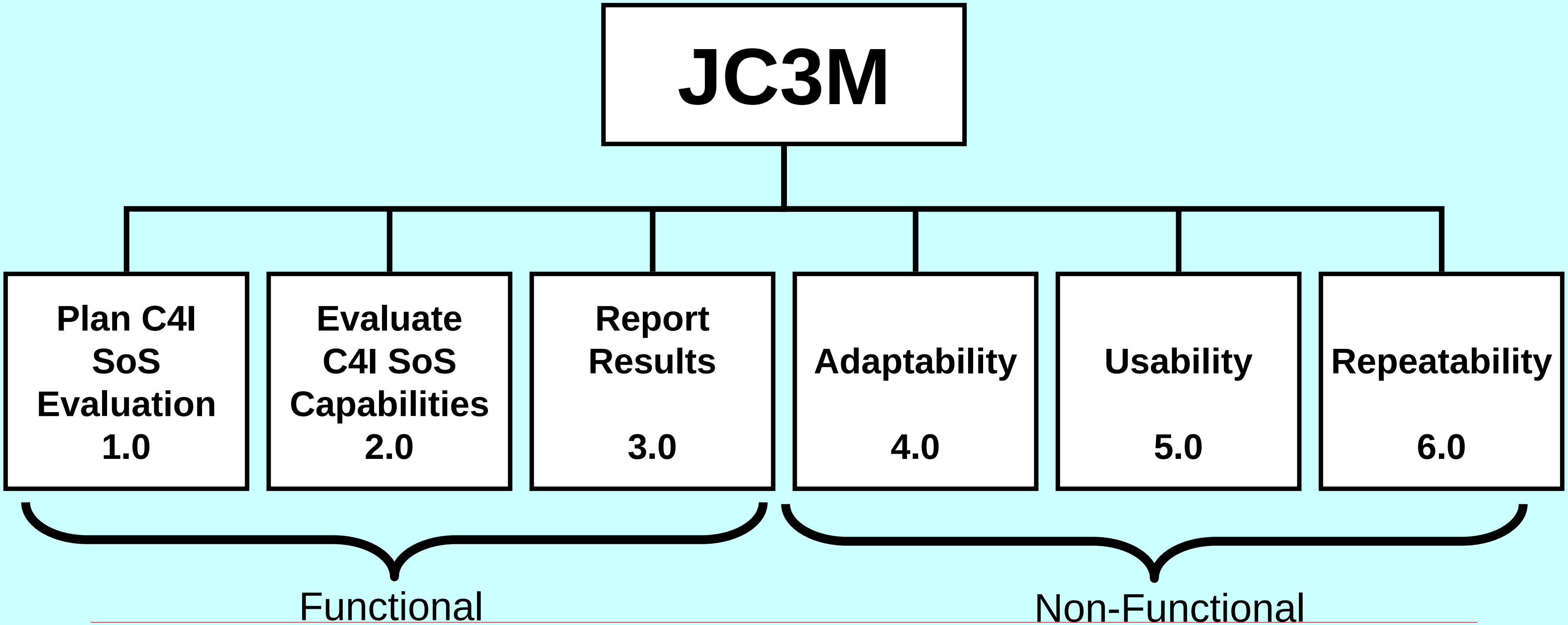


Revised Problem



JC3M Value Hierarchy

- Developed from Refined Problem Statement
- Based on Stakeholder Analysis

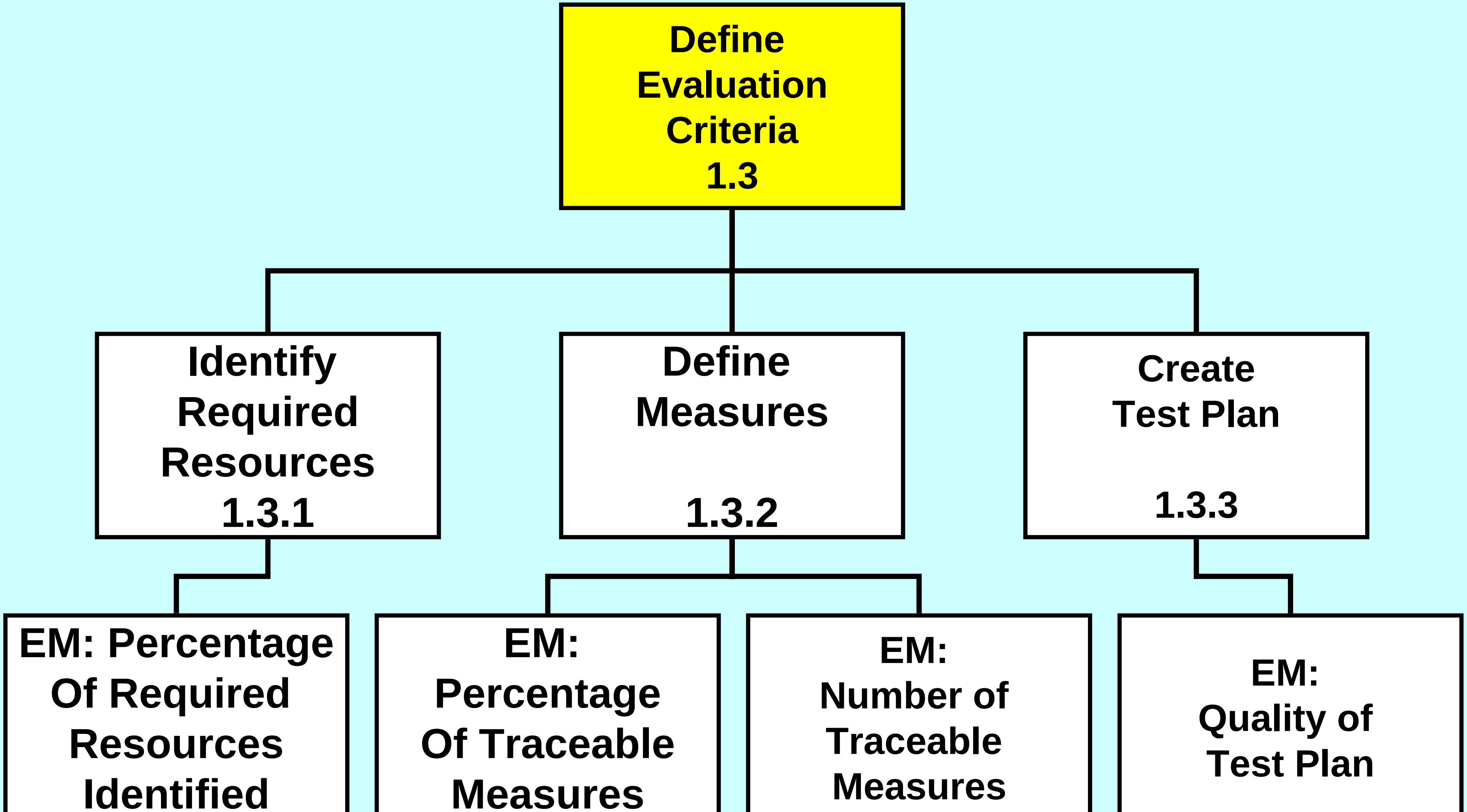


Plan C4I SoS Evaluation

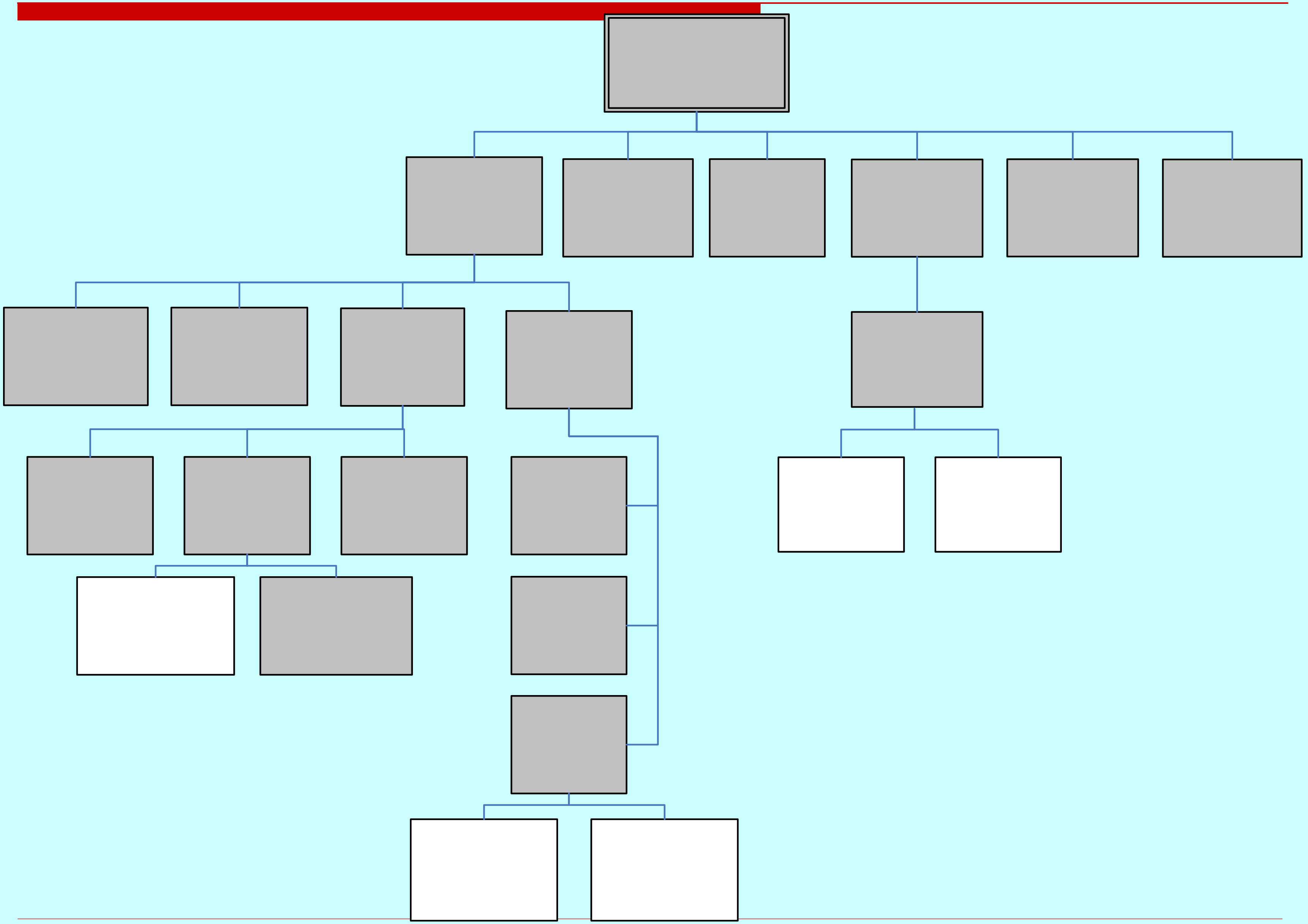
JC3M Functional Decomposition

- **Plan C4I SoS Evaluation 1.0**
  - **Define Problem 1.1**
  - **Define Components 1.2**
  - **Define Evaluation Criteria 1.3**
  - **Ensure Evaluation Readiness 1.4**

Define Evaluation Criteria 1.3



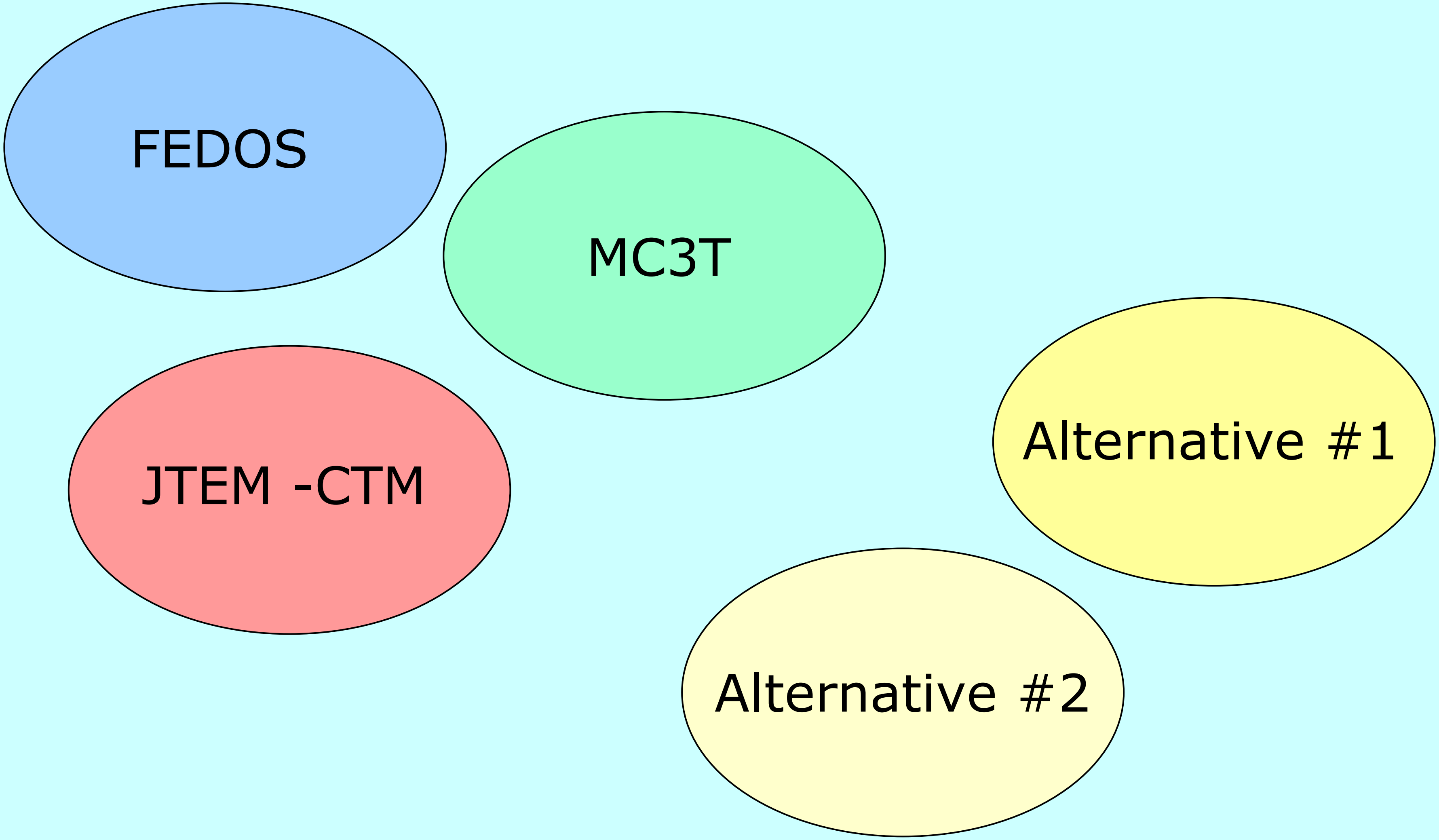
JC3M Value Hierarchy



Evaluation Measures

	Percentage of Traceable Measures	**Days to Plan Evaluation**	**Quality of Planning Outputs**	**Elasticity of Labor**	**Elasticity of Duration**
JC3M Function	Define Measures 1.3.2	Planning Results 1.4.3	Planning Results 1.4.3	Input System Flexibility 4.1	Input System Flexibility 4.1
Definition	Alternative generated measures, traceable to stakeholder requirements, divided by the number of measures generated by the alternative. Ratio level data, from 0 – 100%	Elapsed time (in days) of planning for C4I SoS evaluation Ratio level data ≥ 0 hours	Quantify the overall quality of the planning documents produced. Ordinal – Low, Medium, High	Divide percent change in labor hours to conduct planning phase of JC3M by the percent change in systems under test. (Quantifies ability to scale.) Ratio level data from 0 – ∞	Divide percent change in duration to conduct planning phase of JC3M by the percent change in systems under test. (Quantifies ability to scale.) Ratio level data from 0 – ∞
Rationale and Relevance	Identifies objectivity of performance measures. Performance measures traceable to doctrinal references will be perceived as objective, increasing the value of the evaluation.	Predicts SoS evaluations that can be conducted in a year. Alternatives that permit multiple SoS evaluations generate data to support fielding decisions sooner.	Identifies predicted utility of alternative. Quality of the planning products drives the overall value of the alternative.	Predicts changes in cost of SoS evaluation based on size. Can be used to determine most effective alternative based on SoS size.	Predicts changes in duration of SoS evaluation based on size. Can be used to determine most effective alternative based on SoS size.

Alternatives

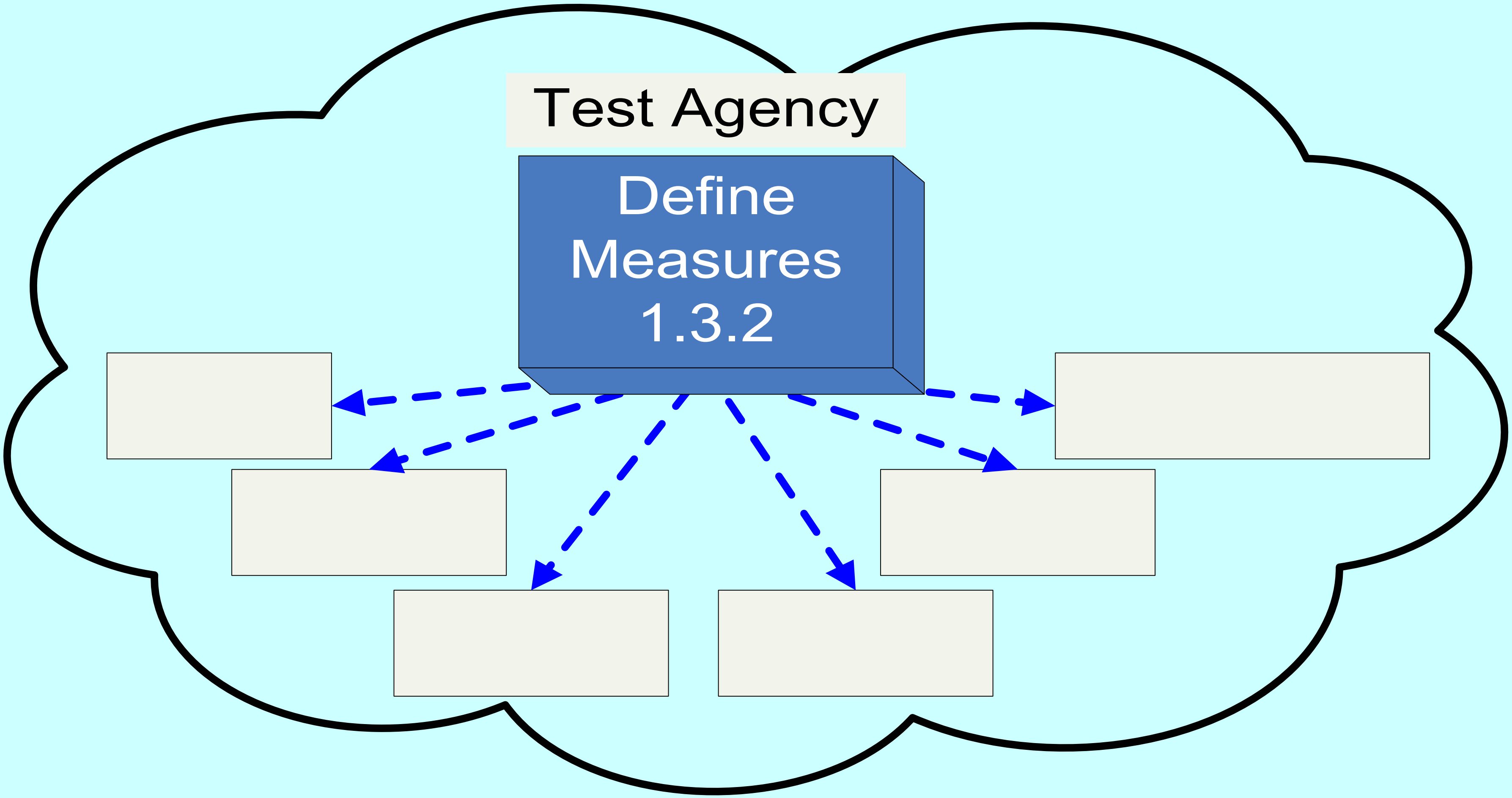


Morphological Box Process

Define the Problem	ID Systems Under Test	Define Criteria	Ensure Readiness
Have SMEs Do It	What PM Requests	Ask Users	PM Review
Acquisition Manager Defines	DoDAF Document Review	What PM Asks For	SAR Review
Acquisition Manager Defines	Engineering Document Review	Test Everything	Test Manager Review
Get from CDD	Ask JITC	Stakeholder Review	

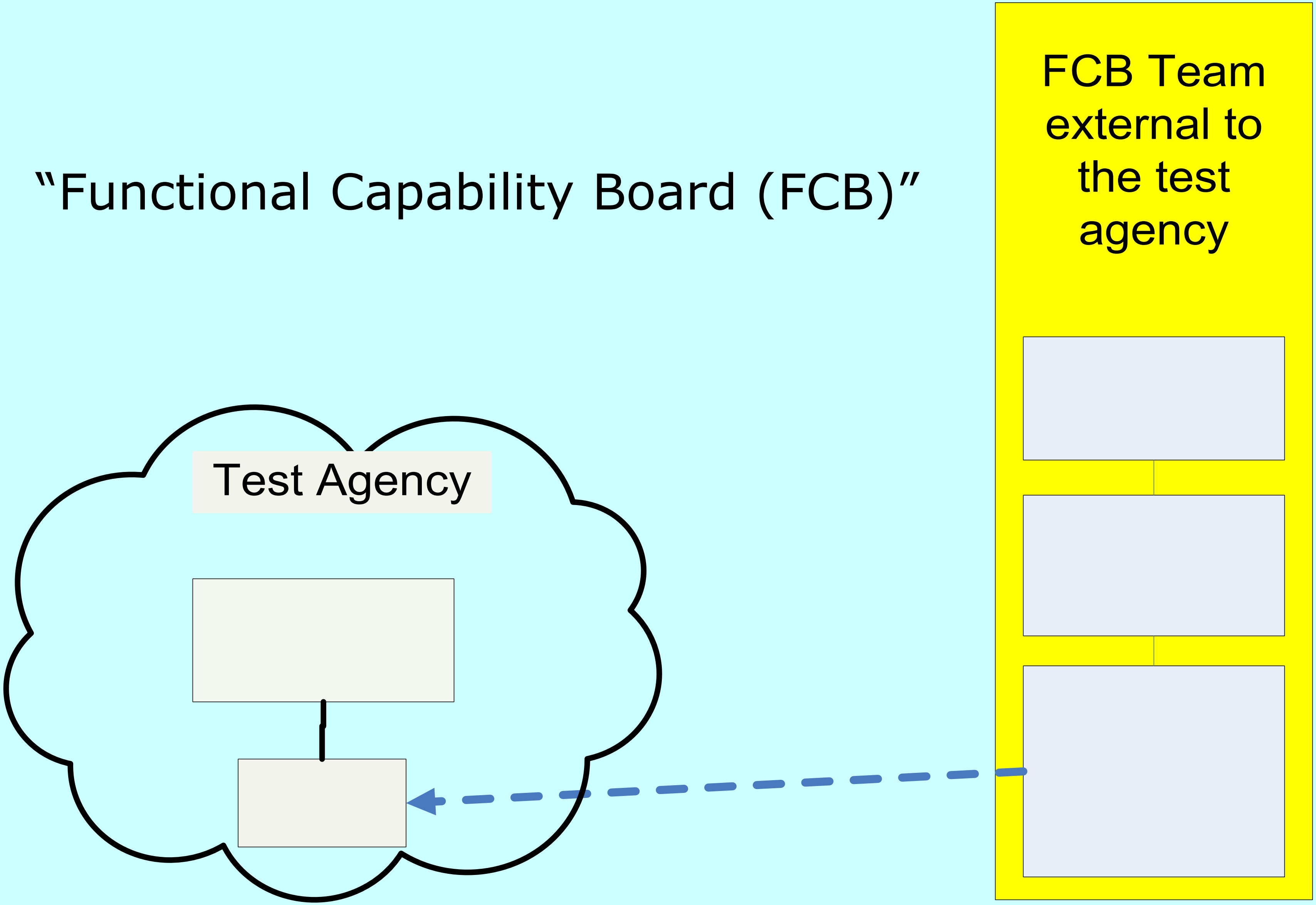
Alternative #1

"System Capabilities Review (SCR)"

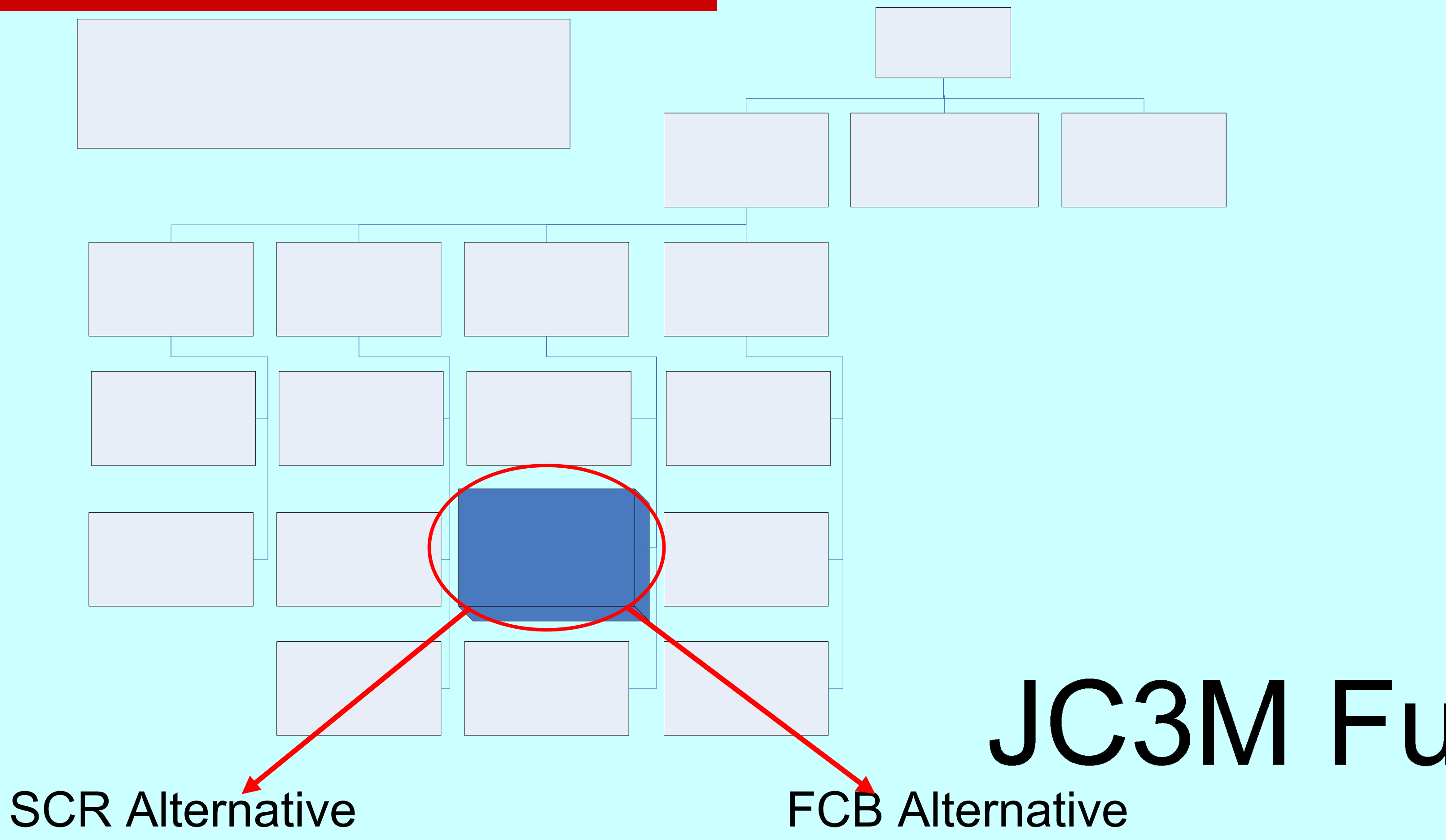


Alternative #2

"Functional Capability Board (FCB)"



Differences



Alternatives Summary

	Personnel	Use	Scope	Measures
FEDOS	Internal	Past	Service **test**	**Stakeholder agreement**
MC3T	Internal + External	Proof of concept	Service system **certification**	Doctrine developers & stakeholders
JTEM CTM	Internal	Model	Joint **Mission Effectiveness** Assessment	Doctrine, System documentation
SCR	Internal	Proposed	**Joint** capability assessment	Doctrine, System documentation
FCB	Internal + External	Proposed	**Joint** capability assessment	**C4I SME panel**

Fill in the blanks!

	Percentage of Traceable Measures	Days to Plan Evaluation	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration
Alternatives	**EM #1: 1.3.2**	**EM #2: 1.4.3**	**EM #3: 1.4.3**	**EM #4: 4.1**	**EM #5: 4.1**
FEDOS					
MC3T					
JTEM - CTM					
FCB					
SCR					

Offline Evaluation

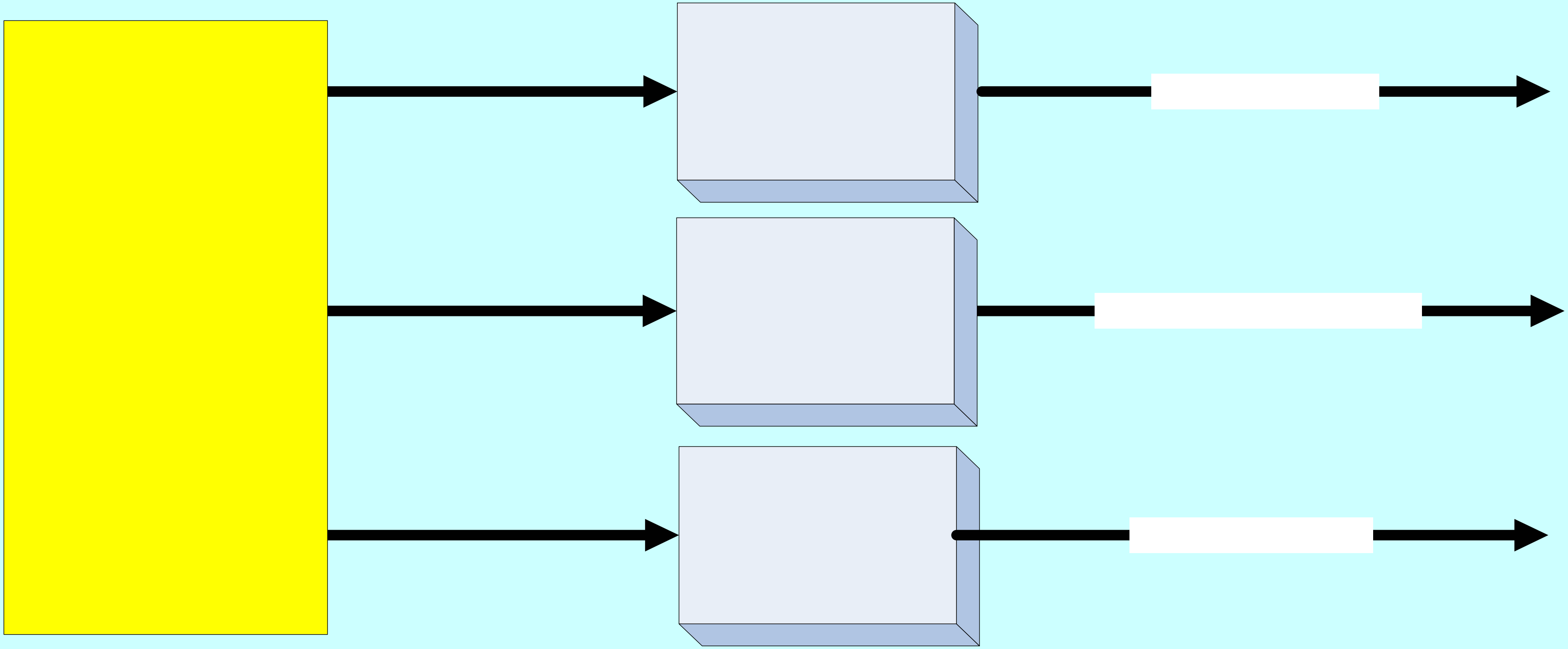
POW-ER

Offline Evaluation

Arena

M&S

M&S Overview



Input

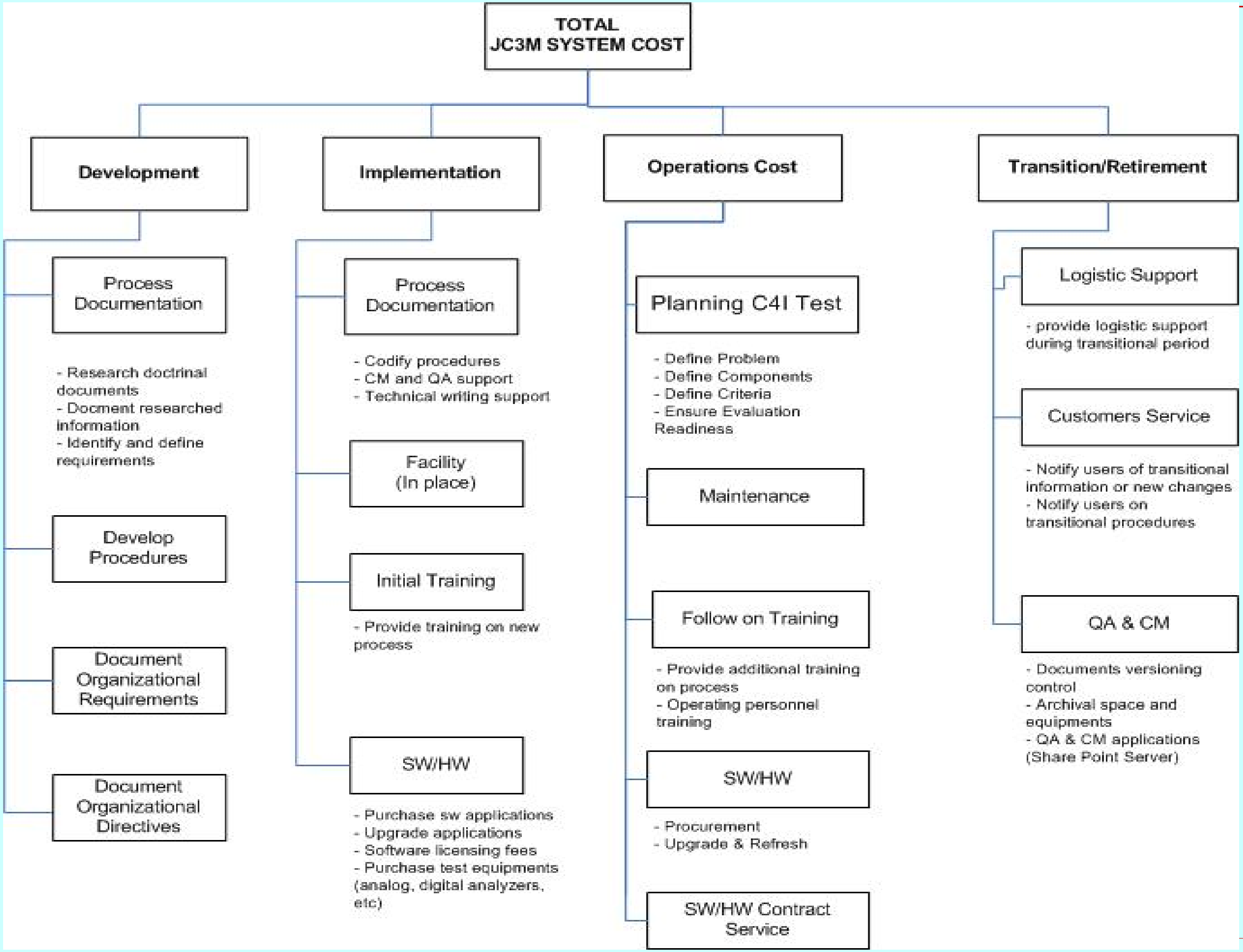
M&S Results

Alternatives	Percentage of Traceable Measures 1.3.2	Days to Plan Evaluation 1.4.3	Quality of Planning Outputs 1.4.3	Elasticity of Labor 4.1	Elasticity of Duration 4.1
FEDOS		140 days		0.87	0.86
MC3T		121 days		0.78	0.78
JTEM CTM		73 days		1.04	0.83
FCB		158 days		0.97	0.97
SCR		127 days		0.71	0.71

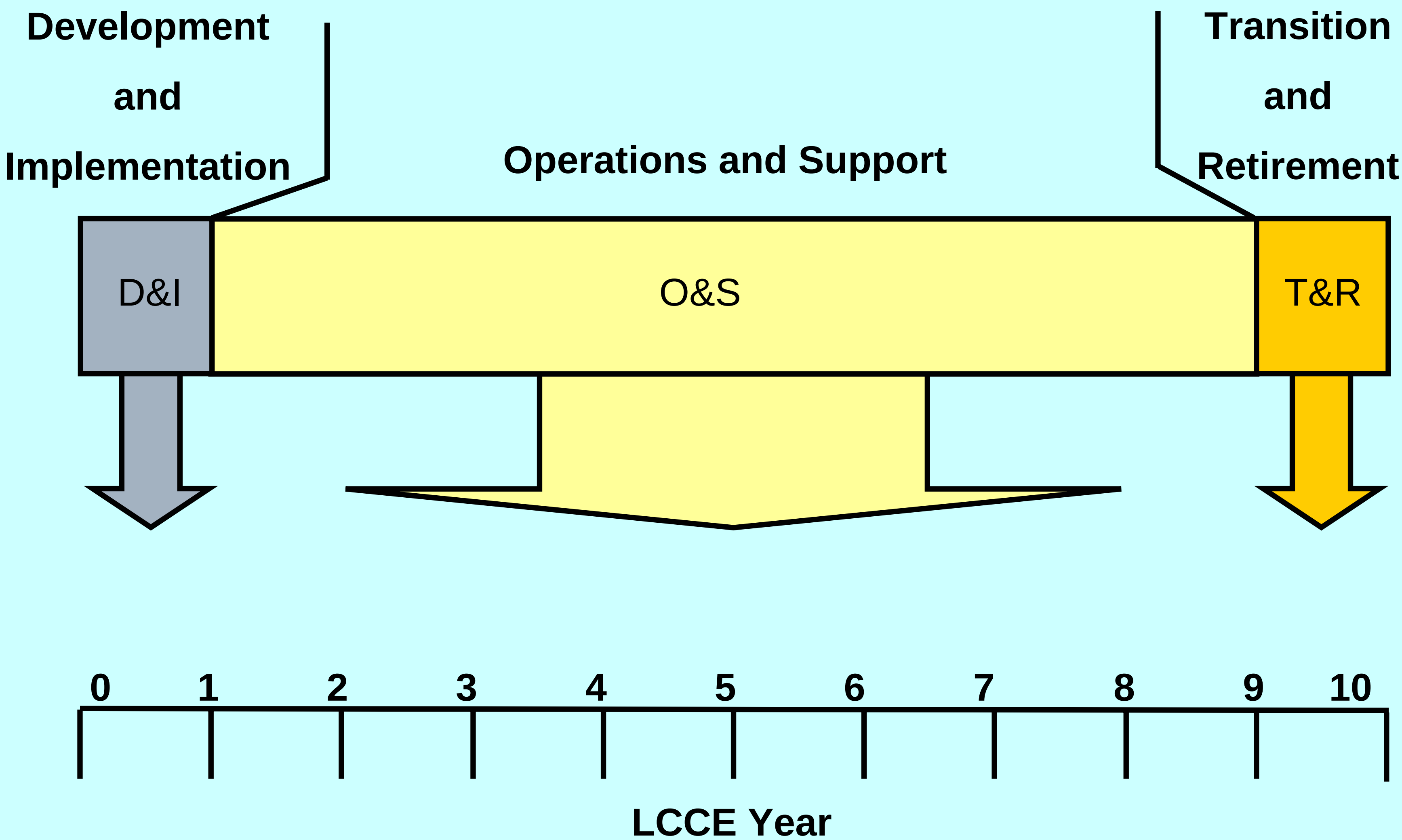
Complete EM

	Percentage Traceable Measures %	Days to Plan Evaluation Days	Planning Output Quality Likert Scale 1-4	Labor Elasticity Unitless	Duration Elasticity Unitless
Ideal Value	**100%**	**Less is better**	**4 is Ideal**	**Less is better**	**Less is better**
FEDOS	0	140	3.17	0.87	0.87
MC3T	72	121	3.25	0.78	0.78
JTEM CTM	**92**	**73**	**3.42**	1.04	0.83
SCR	**92**	158	3.00	0.98	0.98
FCB	88	127	2.75	**0.72**	**0.72**

LCCE – Cost Breakdown Structure



Life Cycle Phases of JC3M



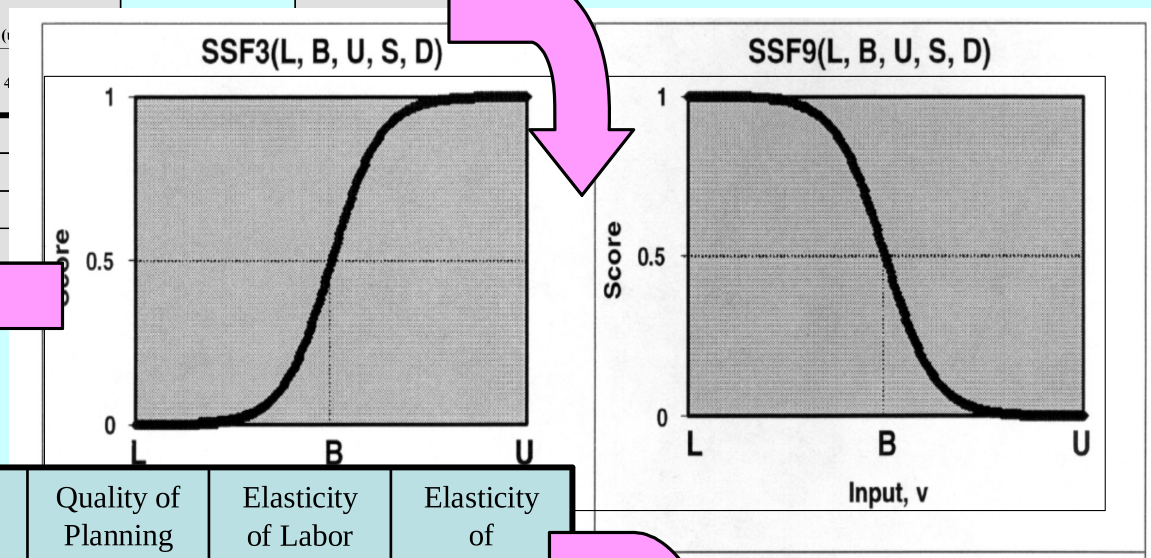
LCCE – Cost Summary

Alternatives	Life-Cycle Year 1	2	3	4…9	10	Total Cost ($)
FEDOS	1,052,527	419,497	419,497	419,497	52,200	**5,010,706**
MC3T	1,169,414	525,537	525,537	525,537	52,200	**5,975,913**
JTEM-CTM	1,030,000	2,470,000	1,169,414	558,535	52,200	**6,972,824**
FCB	2,323,117	650,223	650,223	650,223	52,200	**8,127,101**
SCR	2,121,421	624,451	624,451	624,451	52,200	**7,719,232**

Interpretation: The delta between the highest and lowest LCCE ≈ $3M, which is not a significant sum over a ten year span.

Value Modeling Overview

	Percentage of Traceable Measures (%)	Days to Plan Evaluation (Days)	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration
Ideal Value	100%	Less is better	4		
FEDOS	0	140			
MC3T	72	121			
JTEM CTM	92	73			
SCR	88	127			
FCB	92	158			



	Percentage of Traceable Measures	Days to Plan Evaluation	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration
EM Weights	0.248	0.058			

	Percentage of Traceable Measures	Days to Plan Evaluation	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration	Overall Utility (0 – 1)
FEDOS	0.00	0.04	0.39	0.06	0.14	0.63
MC3T	0.02	0.05	0.39	0.07	0.16	0.71
JTEM CTM	0.24	0.06	0.40	0.04	0.15	0.89
SCR	0.24	0.02	0.37	0.05	0.10	0.79
FCB	0.22	0.05	0.34	0.08	0.18	0.87

Translation of raw measurements into a normalized set of weighted values that can be added.

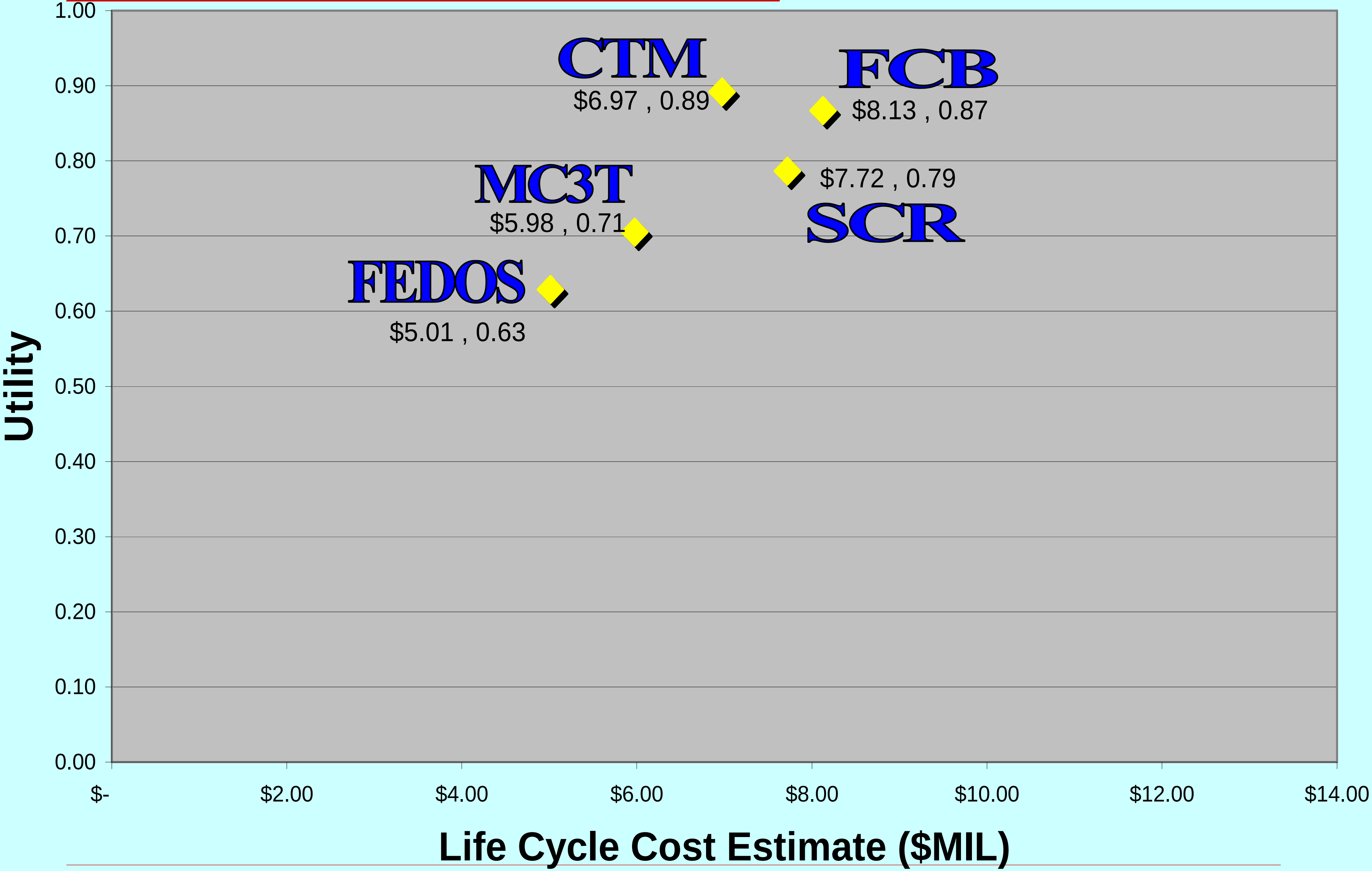
Quantitative Modeling Matrix

	Percentage Traceable Measures	Evaluation Planning Duration	Planning Output Quality	Labor Elasticity	Duration Elasticity	Overall Utility (0 – 1)
FEDOS	0.00	0.04	0.39	0.06	0.14	**0.63**
MC3T	0.02	0.05	0.39	0.07	0.17	**0.71**
JTEM CTM	**0.24**	**0.06**	**0.40**	0.04	0.15	**0.89**
SCR	**0.24**	0.02	0.37	0.05	0.10	**0.79**
FCB	0.22	0.05	0.34	**0.08**	**0.18**	**0.87**

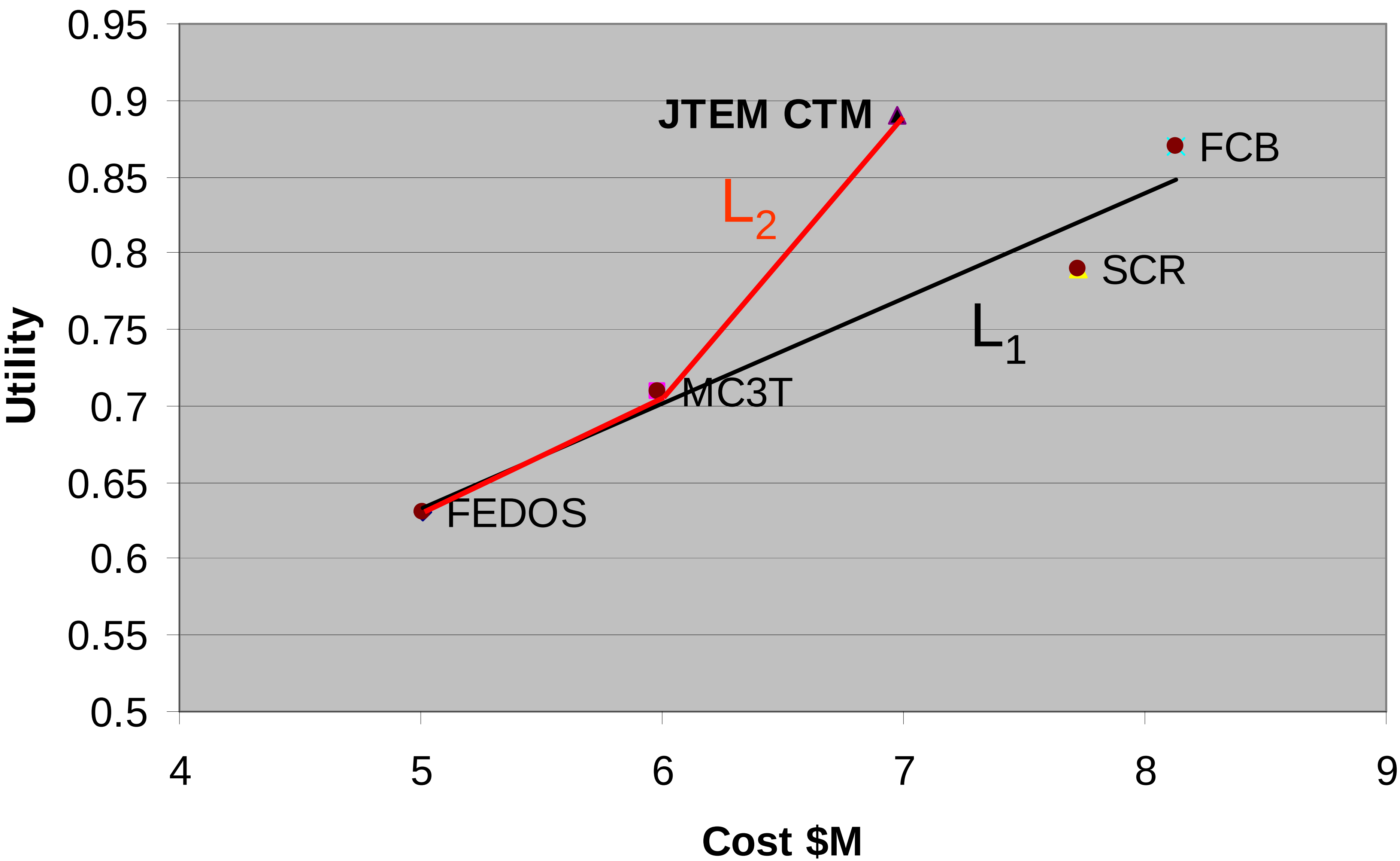
Utility & LCCE

	Percentage of Traceable Measures	Days to Plan Evaluation	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration	Overall Utility (0 – 1)	LCCE ($ M)
FEDOS	0.00	0.04	0.39	0.06	0.14	0.63	5.01
MC3T	0.02	0.05	0.39	0.07	0.17	0.71	5.98
JTEM CTM	0.24	0.06	0.40	0.04	0.15	0.89	6.97
SCR	0.24	0.02	0.37	0.05	0.10	0.79	7.72
FCB	0.22	0.05	0.34	0.08	0.18	0.87	8.13

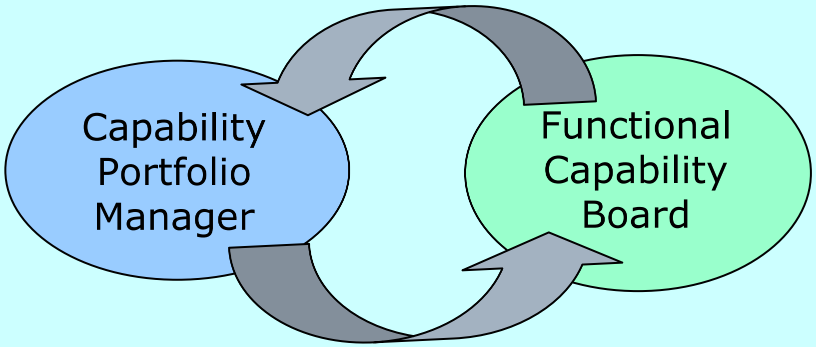
LCCE vs Utility

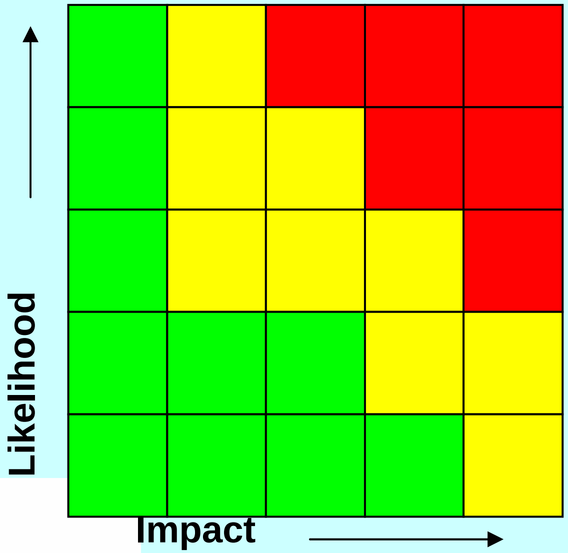


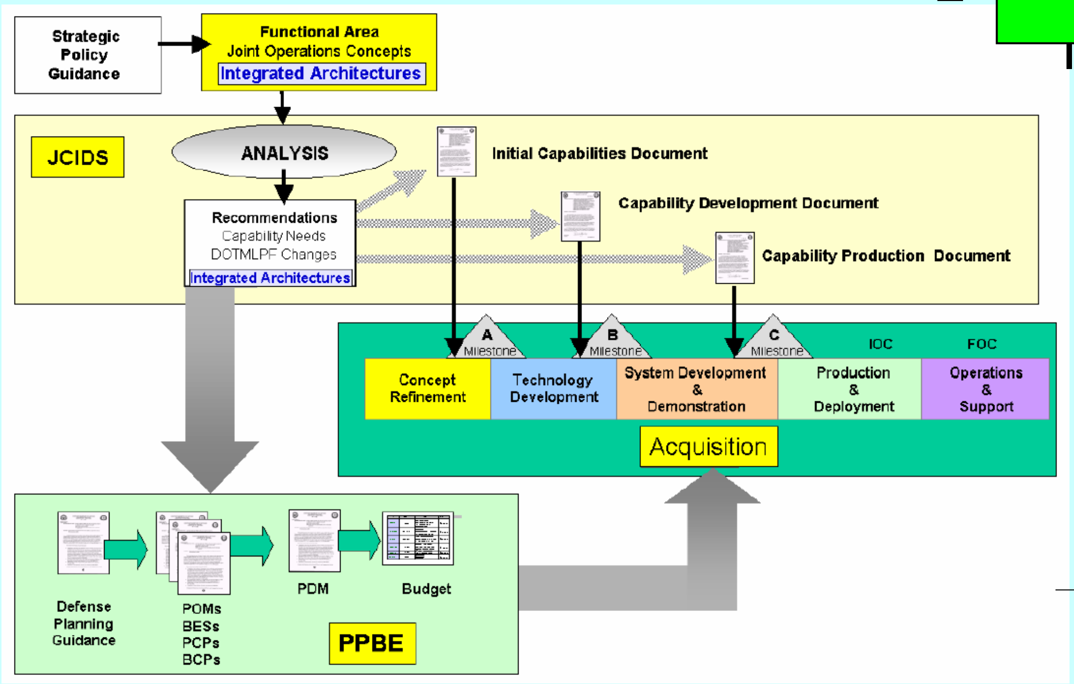
LCCE vs Utility



Way Ahead: 3 areas







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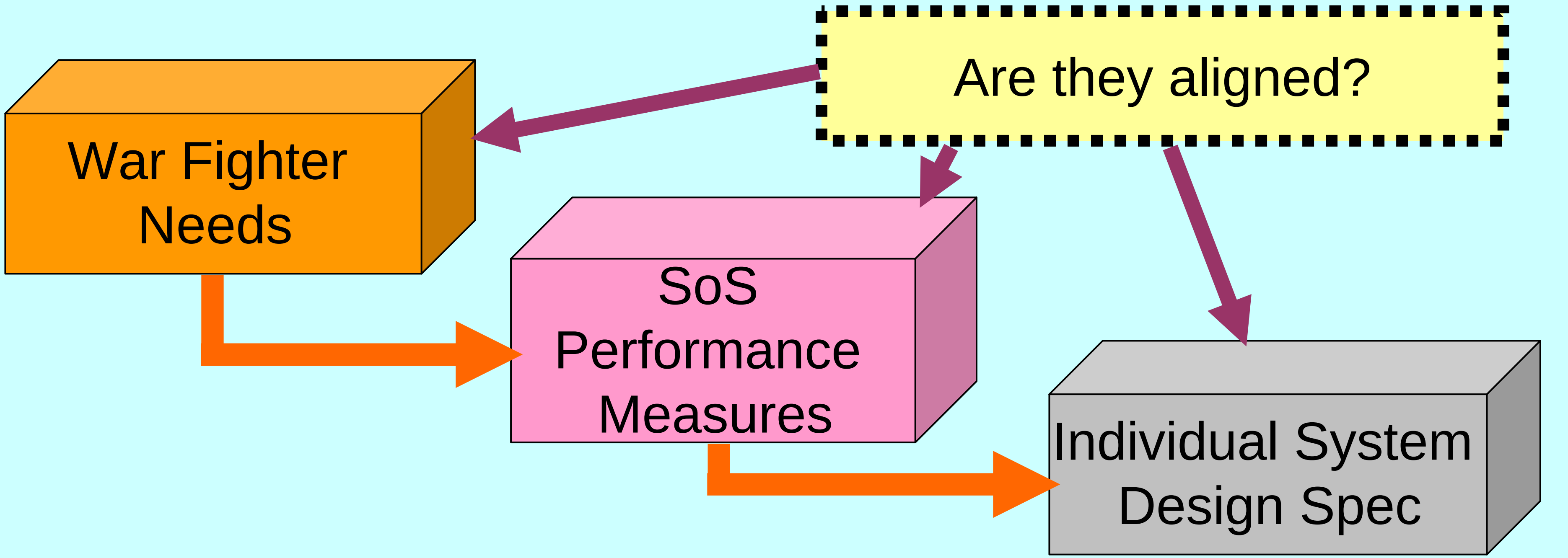
Refined Problem Statement

"There is no system that <u>defines</u> and <u>compares</u> System of System performance measures to war-fighter needs in an objective and measurable way."



Federation Of Systems (FEDOS)

Service Test Organization

System Requirements
System Test Plan
System Test Procedures

Elicit Requirements from Service Stakeholders for each event:

“AFATDS must display unit symbology”

System-Centric Testing

Did AFATDS report ammo status correctly?
Did EPLRS transmit firing data?

Service System “Owners”

Marine Air Ground Task Force C4I Capability Certification Test (MC3T)

Service Test Organization

SoS Capability Assmt Plan
SoS Performance Measures

Capabilities Package from Stakeholders for each event:

"AFATDS must send msg to TBMCS…"

SoS Capability Assessment

Was Call For Fire:
Timely
Reliable
Accurate…

Service
Doctrine Developers
System "Owners"

Joint Test & Evaluation Methodology Capability Test Methodology (JTEM CTM)

Joint Test Organization

Review Joint Doctrine, CONOPS, System Documentation for each event

Pgm Introduction Doc:
- **SoS, SUT, Environment, JOC, COI, MOP, MOE**
- **SoS Evaluation Strategy**

Test Plan

SoS Capability Assessment

Was Call For Fire effective in a Joint Mission environment?
Is XXX an appropriate investment?

Functional Capabilities Board (FCB)

Joint Test Organization

SoS Performance Measures
SoS Test Plan
SoS Test Procedures

Define SoS
Performance Measures
(ongoing)

SoS Capability Evaluation

Was speed (accuracy, effectiveness, efficiency…) improved, unchanged, or degraded?

JCIDS C2 FCB, System Documentation

System Capabilities Review (SCR)

Joint Test Organization

Review Joint Doctrine, CONOPS, System Documentation for each event

SoS Performance Measures
SoS Test Plan
SoS Test Procedures

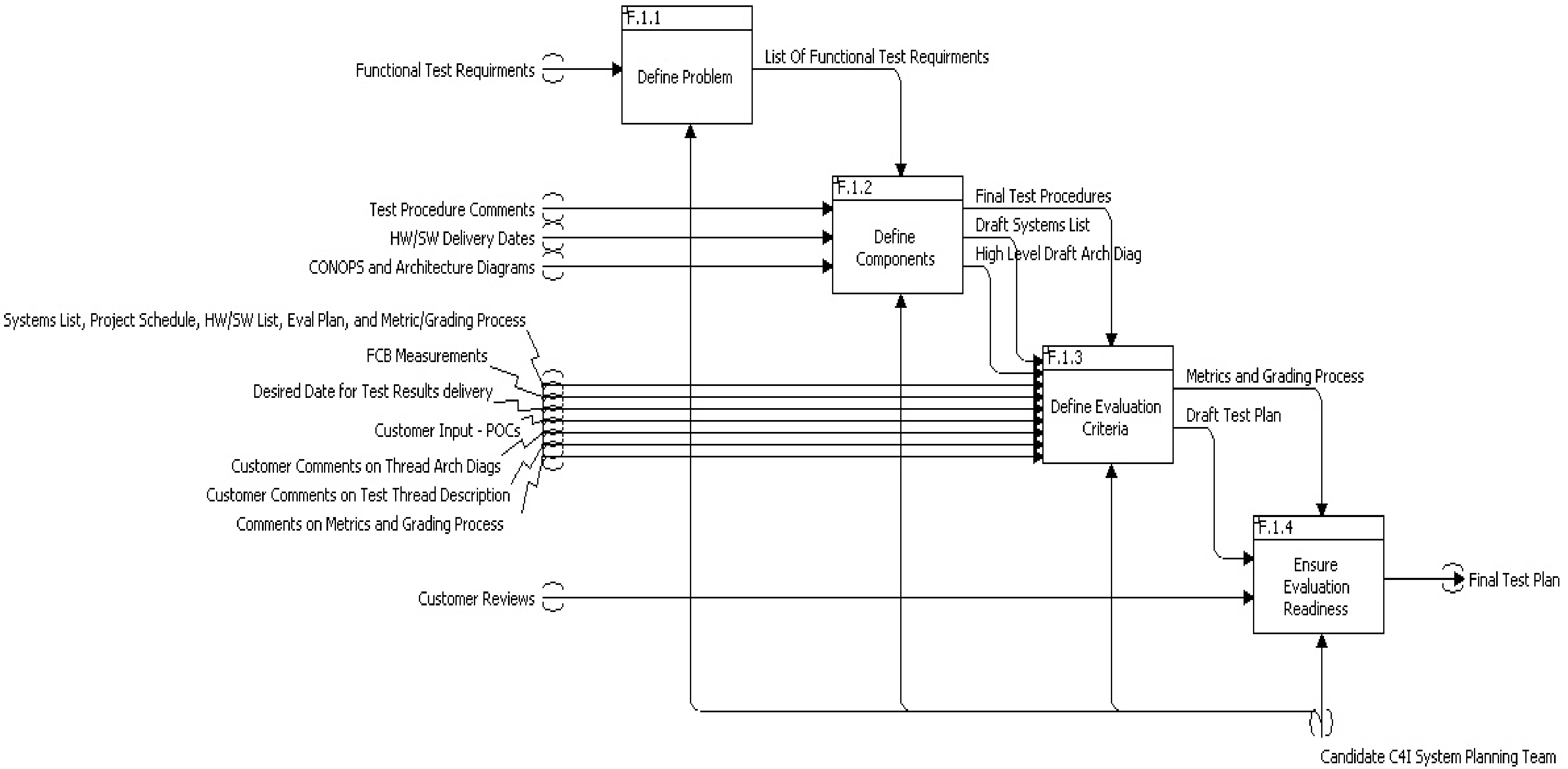
SoS Capability Evaluation

Was speed (accuracy, effectiveness, efficiency…) improved, unchanged, or degraded?

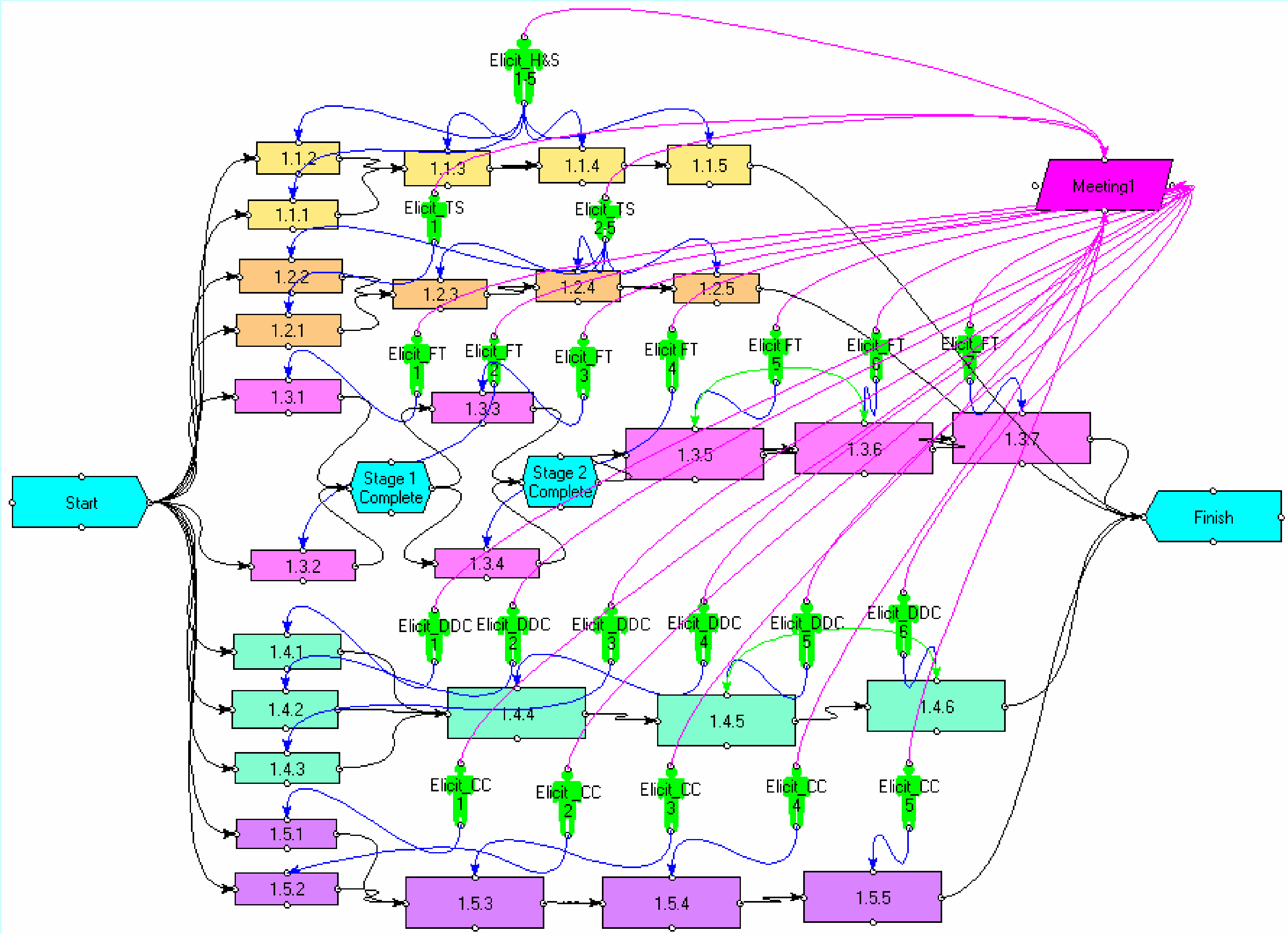
Blank Scoring Matrix

	Percentage of Traceable Measures	Days to Plan Evaluation	Quality of Planning Outputs	Elasticity of Labor	Elasticity of Duration
Alternatives	**1.3.2**	**1.4.3**	**1.4.3**	**4.1**	**4.1**
FEDOS					
MC3T					
JTEM CTM					
FCB					
SCR					

CORE

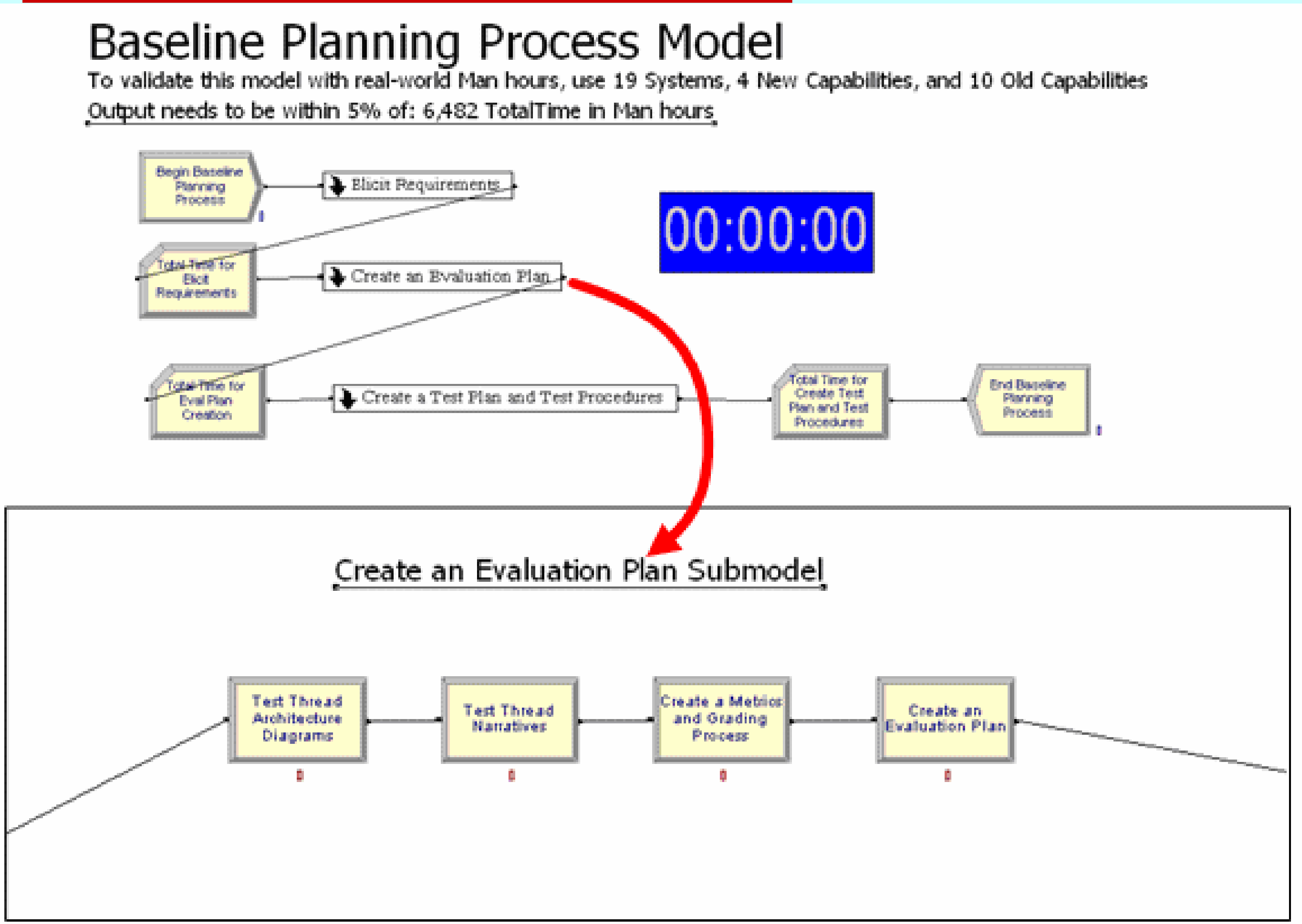

F.1.1
Define Problem
Functional Test Requirments
List Of Functional Test Requirments
F.1.2
Define Components
Test Procedure Comments
HW/SW Delivery Dates
CONOPS and Architecture Diagrams
Final Test Procedures
Draft Systems List
High Level Draft Arch Diag
Systems List, Project Schedule, HW/SW List, Eval Plan, and Metric/Grading Process
FCB Measurements
Desired Date for Test Results delivery
Customer Input - POCs
Customer Comments on Thread Arch Diags
Customer Comments on Test Thread Description
Comments on Metrics and Grading Process
F.1.3
Define Evaluation Criteria
Metrics and Grading Process
Draft Test Plan
F.1.4
Ensure Evaluation Readiness
Customer Reviews
Final Test Plan
Candidate C4I System Planning Team

POW-ER



Elicit_H&S 15
1.1.2
1.1.3
1.1.4
1.1.5
Meeting1
1.1.1
Elicit_TS 1
Elicit_TS 2.5
1.2.2
1.2.3
1.2.4
1.2.5
1.2.1
Elicit_FT 1
Elicit_FT 2
Elicit_FT 3
Elicit_FT 4
Elicit_FT 5
Elicit_FT 6
Elicit_FT 7
1.3.1
1.3.3
1.3.5
1.3.6
1.3.7
Start
Stage 1 Complete
Stage 2 Complete
Finish
1.3.2
1.3.4
Elicit_DDC 1
Elicit_DDC 2
Elicit_DDC 3
Elicit_DDC 4
Elicit_DDC 5
Elicit_DDC 6
1.4.1
1.4.2
1.4.4
1.4.5
1.4.6
1.4.3
Elicit_CC 1
Elicit_CC 2
Elicit_CC 3
Elicit_CC 4
Elicit_CC 5
1.5.1
1.5.2
1.5.3
1.5.4
1.5.5

Arena


Baseline Planning Process Model
To validate this model with real-world Man hours, use 19 Systems, 4 New Capabilities, and 10 Old Capabilities
Output needs to be within 5% of: 6,482 TotalTime in Man hours
Begin Baseline Planning Process
Elicit Requirements
00:00:00
Total Time for Elicit Requirements
Create an Evaluation Plan
Total Time for Eval Plan Creation
Create a Test Plan and Test Procedures
Total Time for Create Test Plan and Test Procedures
End Baseline Planning Process
Create an Evaluation Plan Submodel
Test Thread Architecture Diagrams
Test Thread Narratives
Create a Metrics and Grading Process
Create an Evaluation Plan

Conclusions

- JTEM CTM "wins"
  - Highest score, but . . .
  - . . . not by much
- JTEM CTM cost
  - High development: $3.5M vs $2.3M
  - Lowest O&S: $121,000/year

Information Modeling for Systems Integration

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Claudia.rose@bbi2.com
Alan Brenner
(858) 354-2000
Al.brenner@bbi2.com

BBII
PO Box 90182
San Diego CA 92169

Introduction

The Information Model presented was developed to provide an enterprise solution to information management. It provides a map to the application and integration of program and system elements. The model is tool independent, it provides a guide for modeling and simulation applications, tool capabilities, tailoring and deployment. Model elements and results embedded within the Information Model and tools are customized to automate the workflow defined in the model including the production of work products.

Following this modeling approach creates a daily work environment that facilitates integrated data development following preferred processes and reflecting modeling results in further proposals and products. Once the workflow and processes become an integral part of the data development it becomes easier to understand the impact of discoveries and changes on the program. This in turn supports ease of identifying solutions to integration and development problems. Ingenuity in design allowing program development to utilize existing structures in new ways is enabled through this approach.

In addition using an information model approach allows simultaneous "live" views of the data from different concerns including management and IPTs. The inclusion of program concerns such as Risk and Test gives a more complete response to problems and issues in those areas.

About Us

BBII provides experts in Systems Engineering and Architecture. The company has developed an Information Model approach to integrating program functions. Customers include Bombardier, Northrop Grumman, NASA, SAIC, Sikorsky, the State of Texas, ViaSat, and others. BBII has maintained partnerships with a variety of tool vendors. BBII can provide a team to identify the model, modify the tools, write instructions, mentor and train staff, develop data, provide systems engineers, systems architects and engineering support.

Claudia Rose is the president and creator of BBII, a Systems Engineering Consulting and Support Company. She has presented papers on Systems Engineering tools and processes at INCOSE, NDIA and AFCEA conferences and others. She has served on boards of directors in recent years that include INCOSE San Diego, NDIA small business forum, AUVSI and the La Jolla Cove Swim Club. She holds an MAIT (Master International Transactions) from George Mason University, with studies Tribhuvan University Kathmandu, and a BA from the University of Wisconsin-Madison. Her research has focused on bringing order out of chaos. She has worked as a consultant on Health and Development projects at The World Bank and USAID, presented papers on the health development policy process, created databases for canning companies and personal trainers, before bringing the special organization credo of BBII to the world of systems engineering.

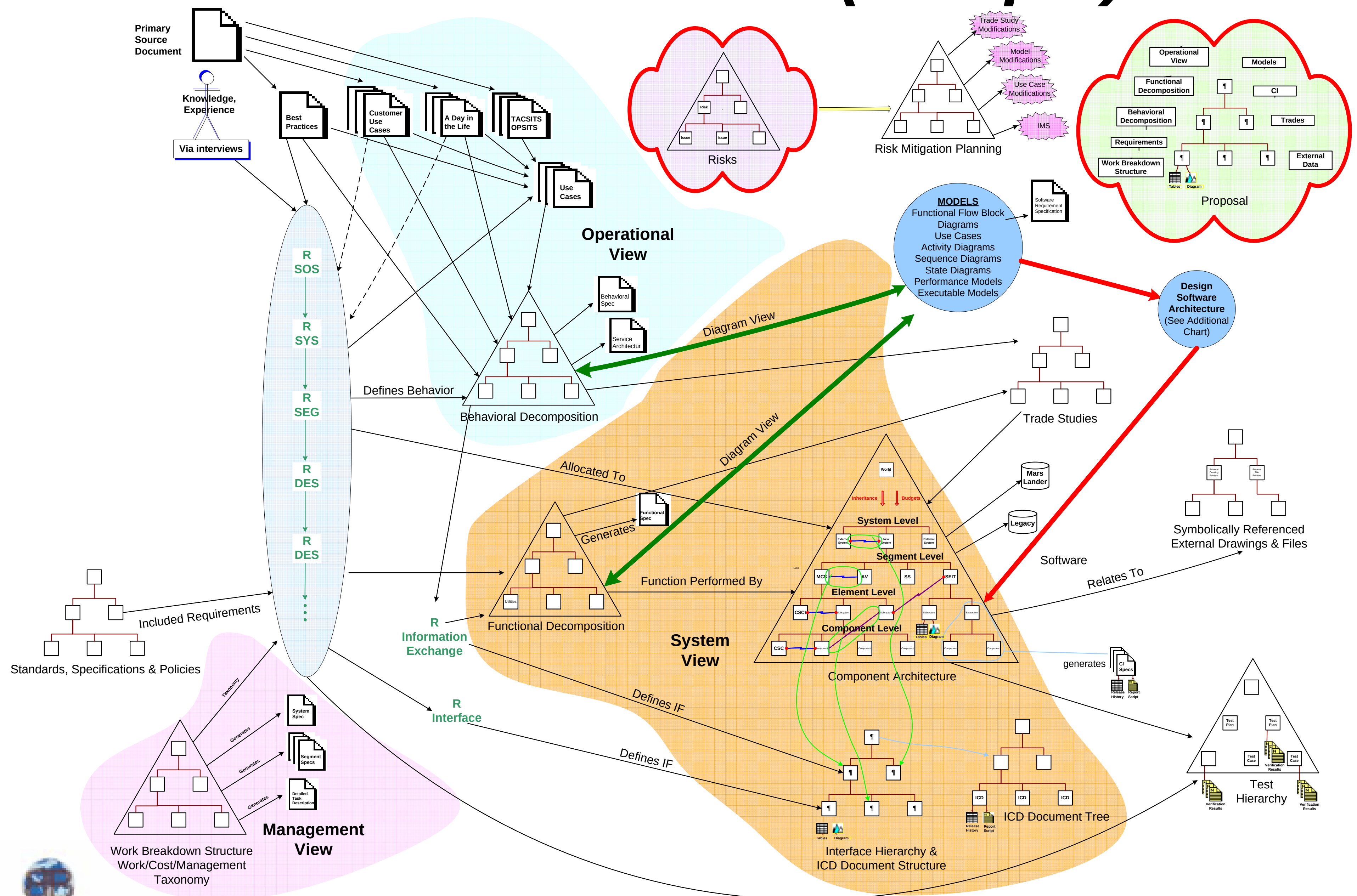
Information Model Benefits

- OPTIMAL DESIGN
  - The information model facilitates a design where gaps in the satisfaction of operational needs drive an adaptive solution to reduce the gap
  - The information model facilitates the development of alternative approaches at higher levels, up to re-characterization of the operational needs, to allow an overall design solution which better satisfies the operational needs of the platform
  - Characterized by measures of effectivity
- ENTERPRISE ARCHETECTURE
  - Tie together stakeholders and represent their needs
  - Tie together System Elements
  - Integrate Management
- WORKFLOW AUTOMATION
  - Allows information to be viewed in its entire context
  - Work products including specifications and reports are produced as byproducts of the database
  - Collaboration is supported as part of the workflow
- DESIGN ASSURANCE
  - Disciplined Systems Engineering process
  - Validation
  - Verification

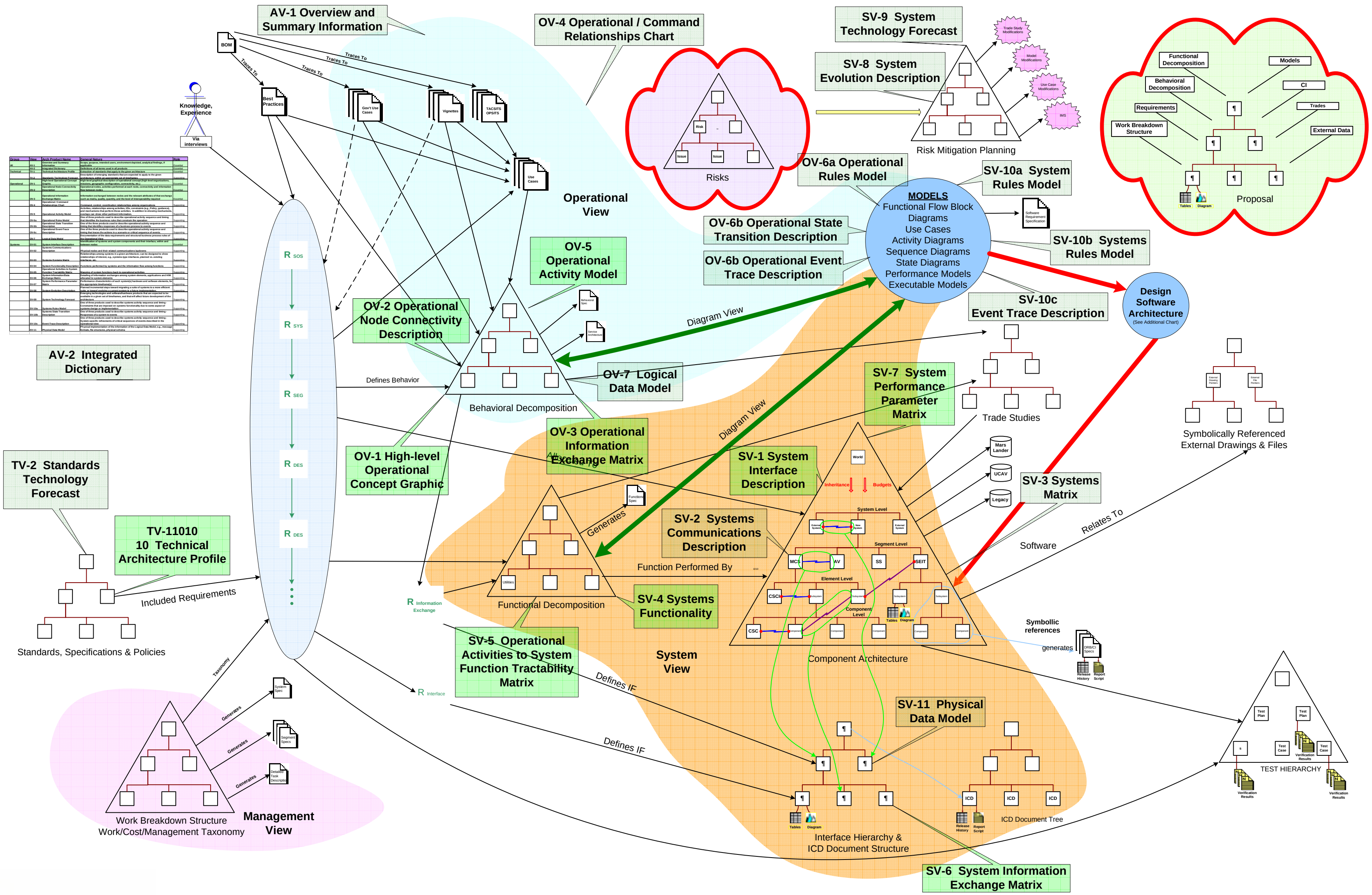
Why this Approach?

- Providing the best value solutions
- Use of modeling and tools that allow team members to collaboratively integrate their work with the entire program
- Collaborating to produce better options with existing resources
- Finding new ways to accomplish new objectives within existing framework
- Identifying and evaluating options throughout the program development process
- Re-characterize statements of need and higher level requirements to allow innovative and ingenious solutions

Information Model (Sample)

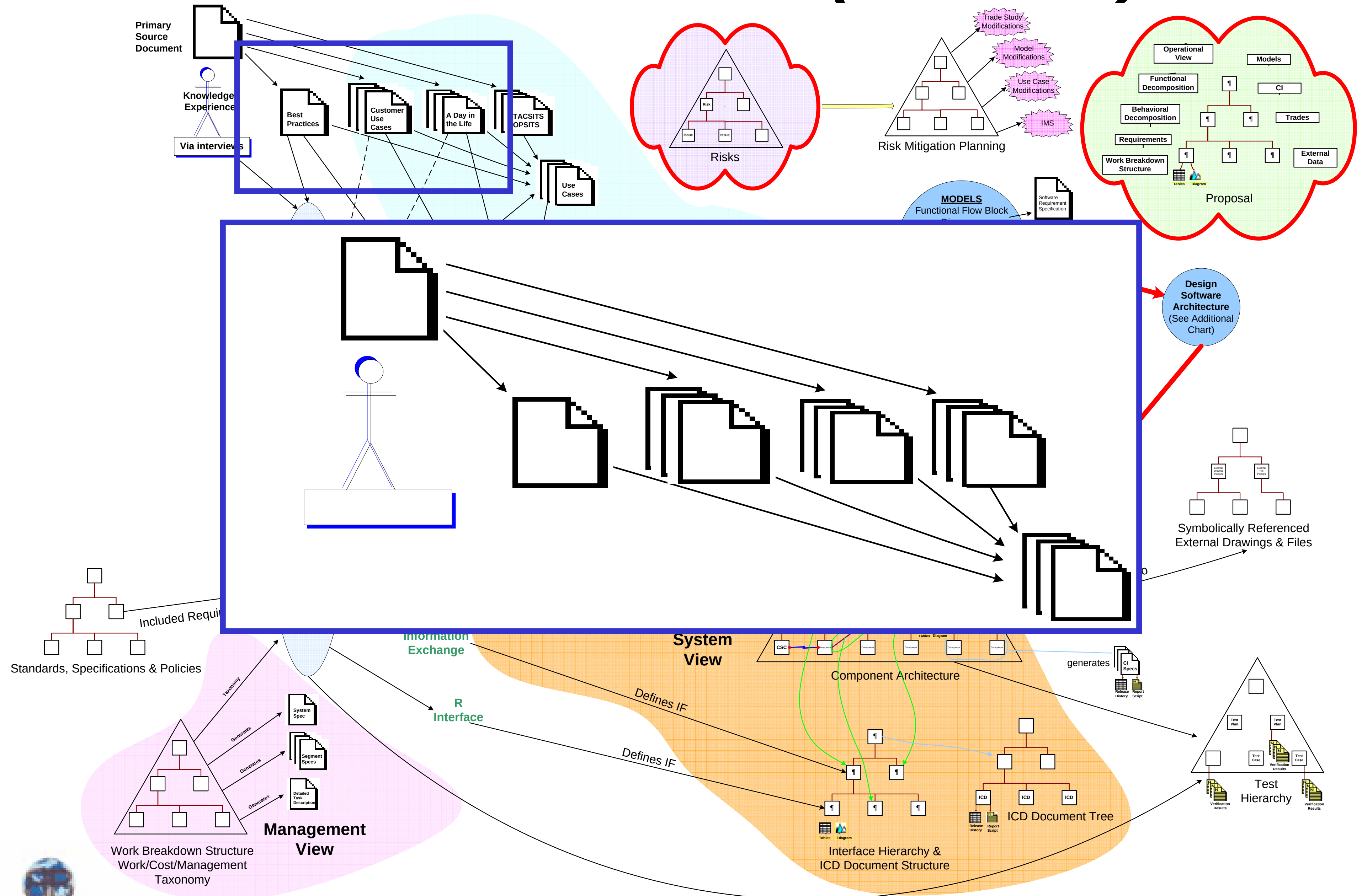


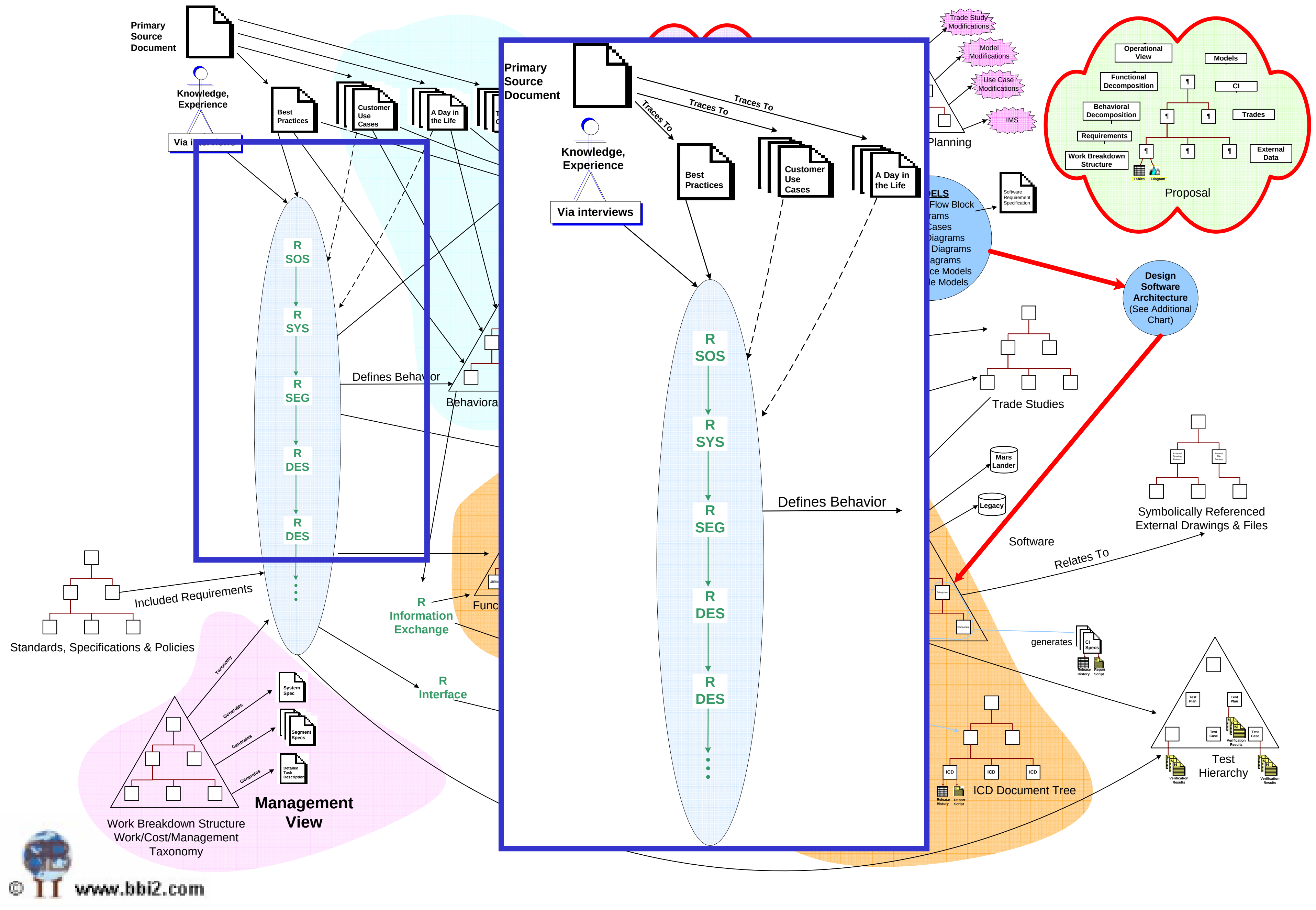
DoD-AF



AV-1 Overview and Summary Information
OV-4 Operational / Command Relationships Chart
SV-9 System Technology Forecast
SV-8 System Evolution Description
Risk Mitigation Planning
Risks
Proposal
Functional Decomposition
Behavioral Decomposition
Models
CI
Requirements
Trades
Work Breakdown Structure
External Data
Tables
Diagram
BOM
Traces To
Best Practices
Gov't Use Cases
Vignettes
TACSITS OPSITS
Use Cases
Knowledge, Experience
Via interviews
Operational View
OV-6a Operational Rules Model
SV-10a System Rules Model
MODELS
Functional Flow Block Diagrams
Use Cases
Activity Diagrams
Sequence Diagrams
State Diagrams
Performance Models
Executable Models
Software Requirement Specification
OV-6b Operational State Transition Description
OV-6b Operational Event Trace Description
SV-10b Systems Rules Model
OV-5 Operational Activity Model
Design Software Architecture
(See Additional Chart)
SV-10c Event Trace Description
OV-2 Operational Node Connectivity Description
Diagram View
R SOS
R SYS
R SEG
R DES
AV-2 Integrated Dictionary
Defines Behavior
OV-7 Logical Data Model
Behavioral Decomposition
SV-7 System Performance Parameter Matrix
Trade Studies
Symbolically Referenced External Drawings & Files
OV-3 Operational Information Exchange Matrix
OV-1 High-level Operational Concept Graphic
SV-1 System Interface Description
Mars Lander
UCAV
Legacy
World
Inheritance
Budgets
System Level
Segment Level
Element Level
Component Level
SV-3 Systems Matrix
TV-2 Standards Technology Forecast
TV-11010 10 Technical Architecture Profile
Generates
Functional Spec
SV-2 Systems Communications Description
Software
Relates To
Function Performed By
Included Requirements
Standards, Specifications & Policies
R Information Exchange
SV-4 Systems Functionality
Functional Decomposition
Symbollic references
generates
SV-5 Operational Activities to System Function Tractability Matrix
System View
Component Architecture
Taxonomy
System Spec
Segment Specs
Detailed Task Description
R Interface
Defines IF
SV-11 Physical Data Model
Work Breakdown Structure
Work/Cost/Management Taxonomy
Management View
ICD
ICD Document Tree
Interface Hierarchy & ICD Document Structure
Test Plan
Test Case
Verification Results
TEST HIERARCHY
SV-6 System Information Exchange Matrix

Information Model (Sources)





Primary Source Document
Knowledge, Experience
Via interviews
Best Practices
Customer Use Cases
A Day in the Life
Traces To
Traces To
Traces To
R SOS
R SYS
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R DES
Defines Behavior
Behavioral
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Standards, Specifications & Policies
Taxonomy
Generates
Generates
Generates
System Spec
Segment Specs
Detailed Task Description
Management View
Work Breakdown Structure Work/Cost/Management Taxonomy
R Information Exchange
R Interface
Trade Study Modifications
Model Modifications
Use Case Modifications
IMS
Planning
Software Requirement Specification
Operational View
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Relates To
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generates
CI Specs
Release History
Report Script
ICD
ICD
ICD
ICD Document Tree
Test Plan
Test Plan
Test Case
Test Case
Verification Results
Test Hierarchy
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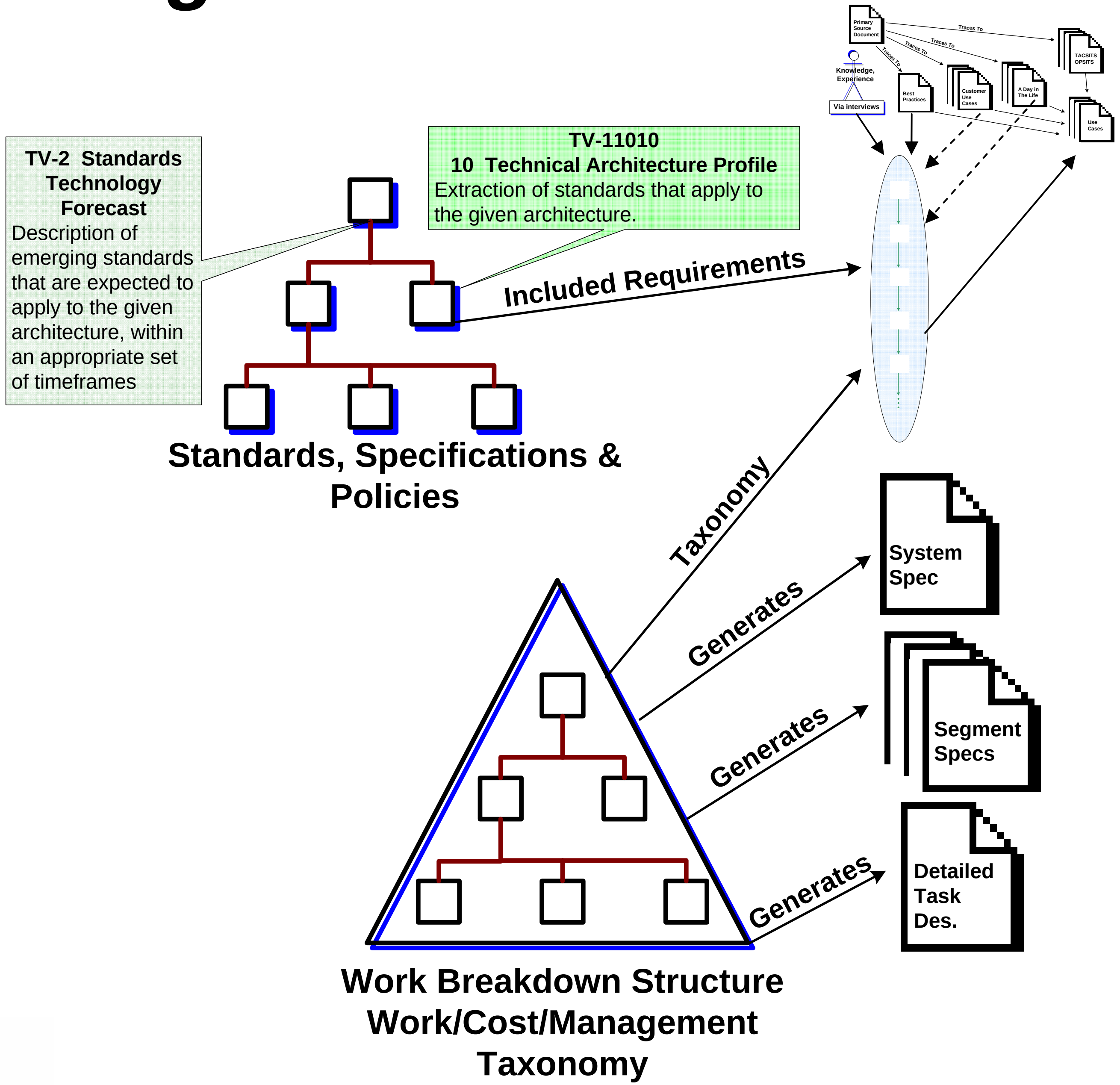
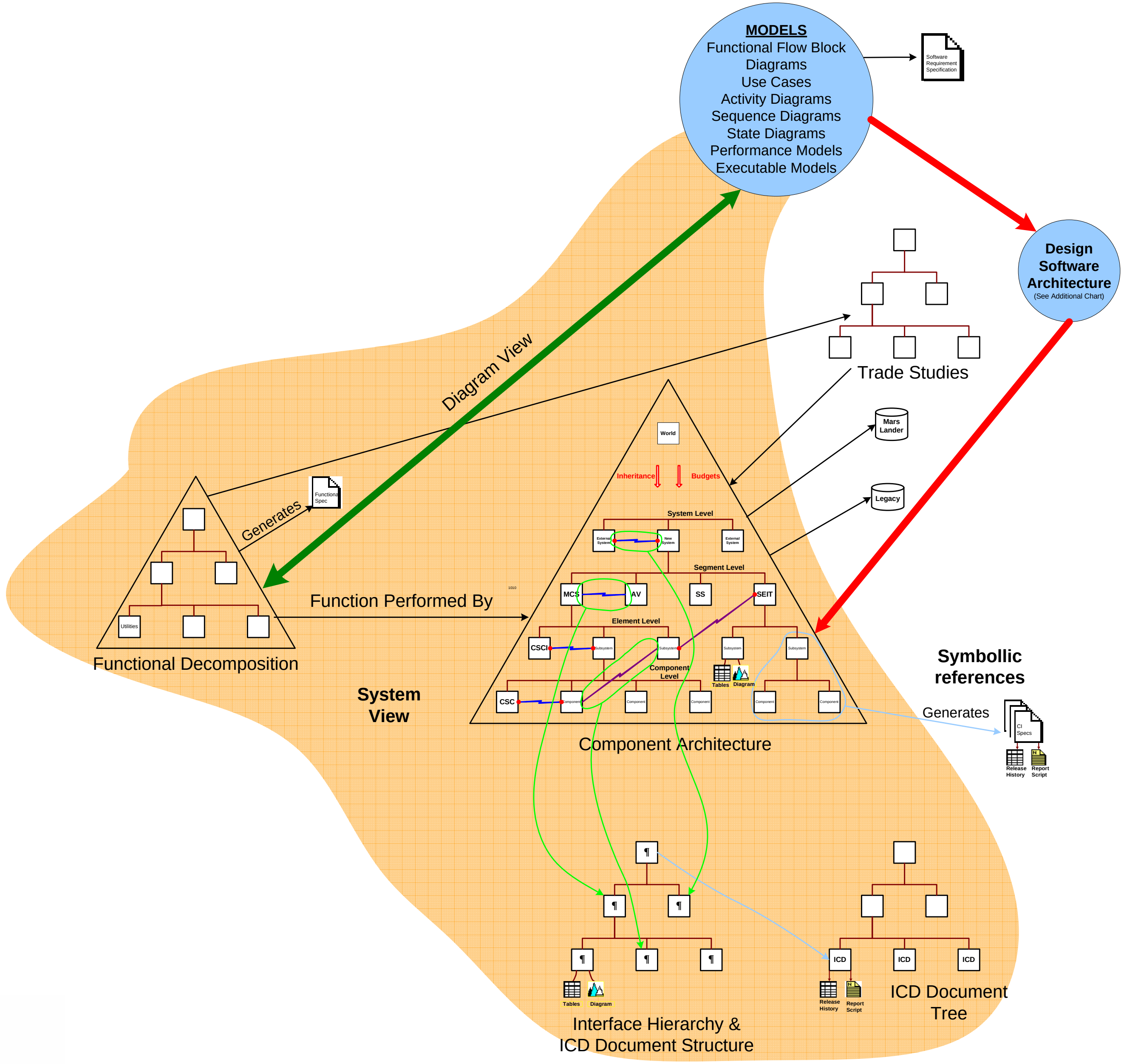
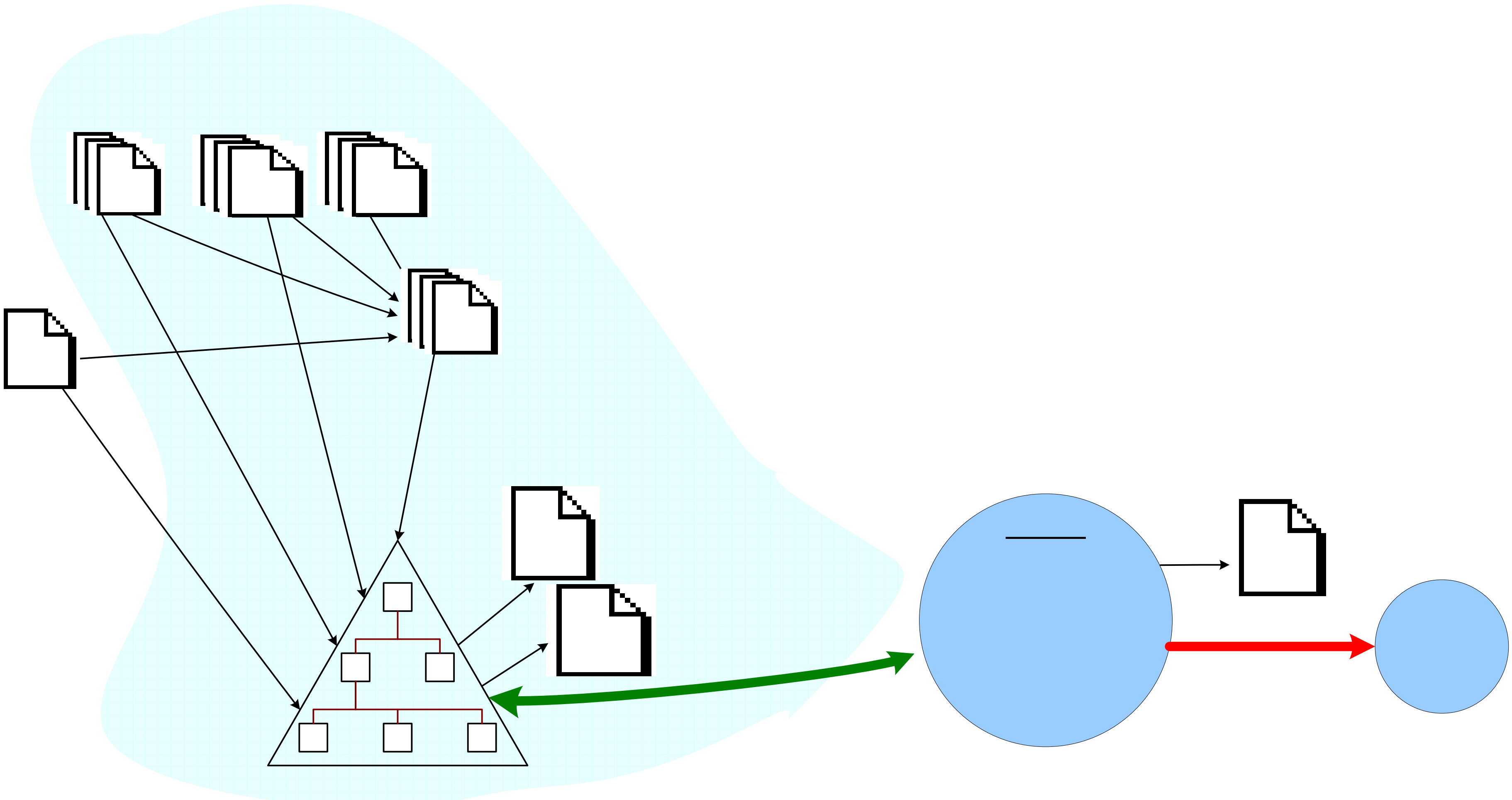
Management View and Standards



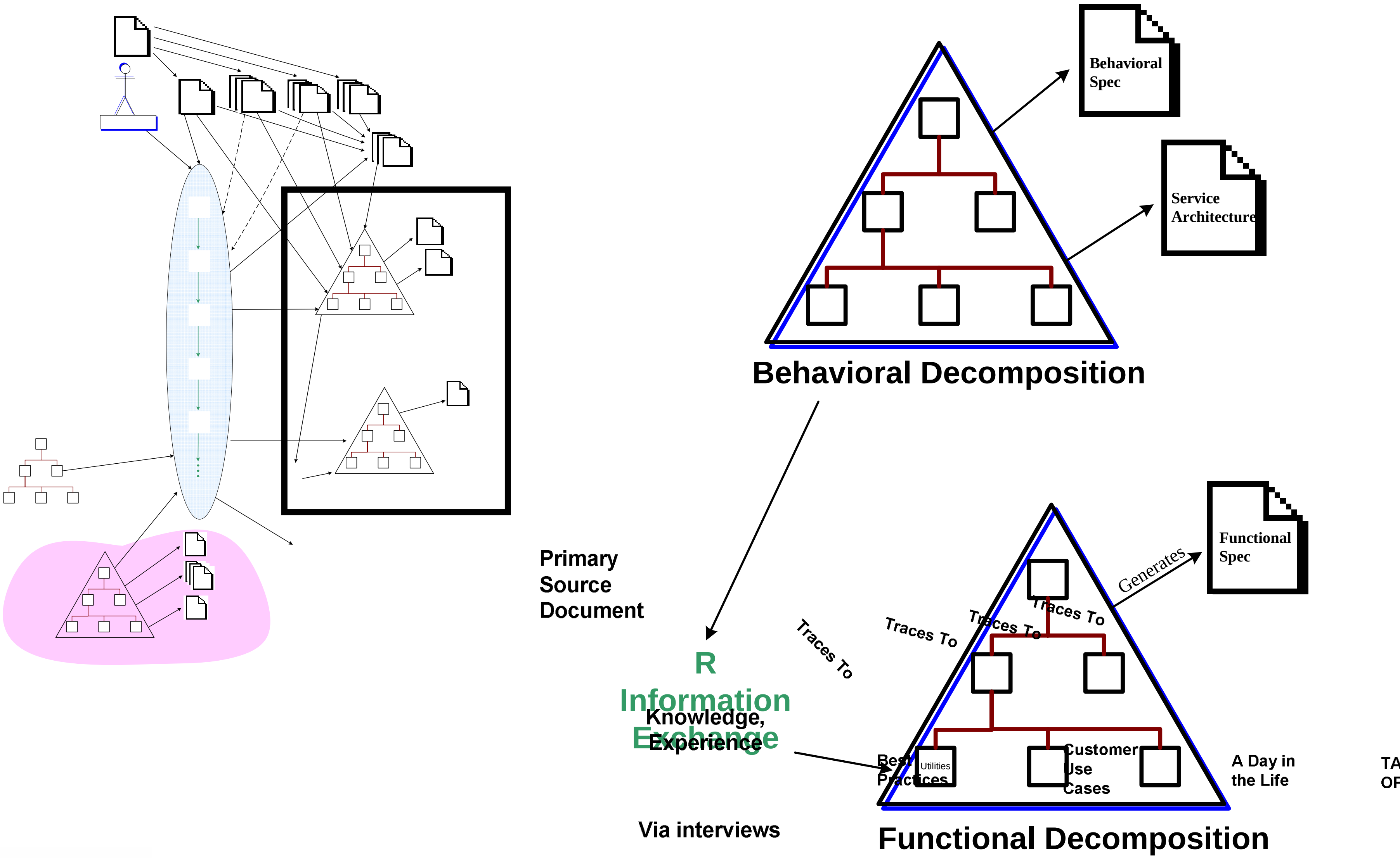
System View


MODELS
Functional Flow Block Diagrams
Use Cases
Activity Diagrams
Sequence Diagrams
State Diagrams
Performance Models
Executable Models
Software Requirement Specification
Design Software Architecture
(See Additional Chart)
Trade Studies
Diagram View
Generates
Functional Spec
Utilities
Functional Decomposition
Function Performed By
Mars Lander
Legacy
World
Inheritance
Budgets
System Level
Segment Level
MCS
AV
SS
SEIT
Element Level
CSCI
Component Level
Tables
Diagram
CSC
Component Architecture
System View
Symbollic references
Generates
CI Specs
Release History
Report Script
Interface Hierarchy & ICD Document Structure
ICD
ICD Document Tree

Operational View



Decomposition

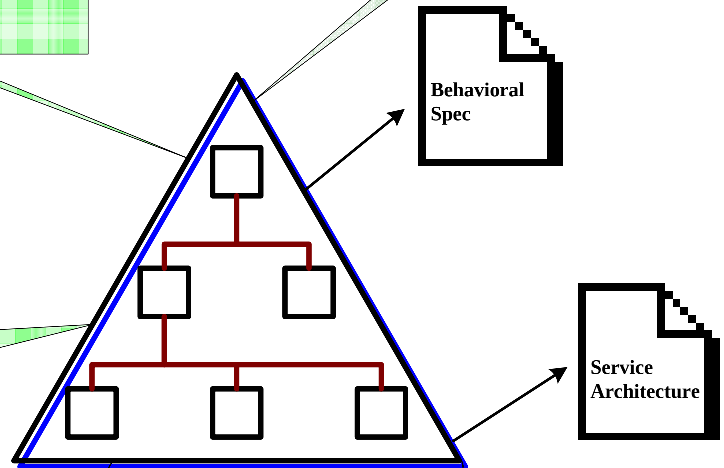


Decomposition OV examples

OV-5 Operational Activity Model
Activities, relationships among activities, I/Os, constraints (e.g., Policy, guidance), and mechanisms that perform those activities. In addition to showing mechanisms, overlays can show other pertinent information.

OV-7 Logical Data Model
Documentation of the data requirements and structural business process rules of the Operational View

OV-1 High-level Operational Concept Graphic
High-level graphical description of operational concept (high-level organizations, missions, geographic configuration, connectivity, etc.)

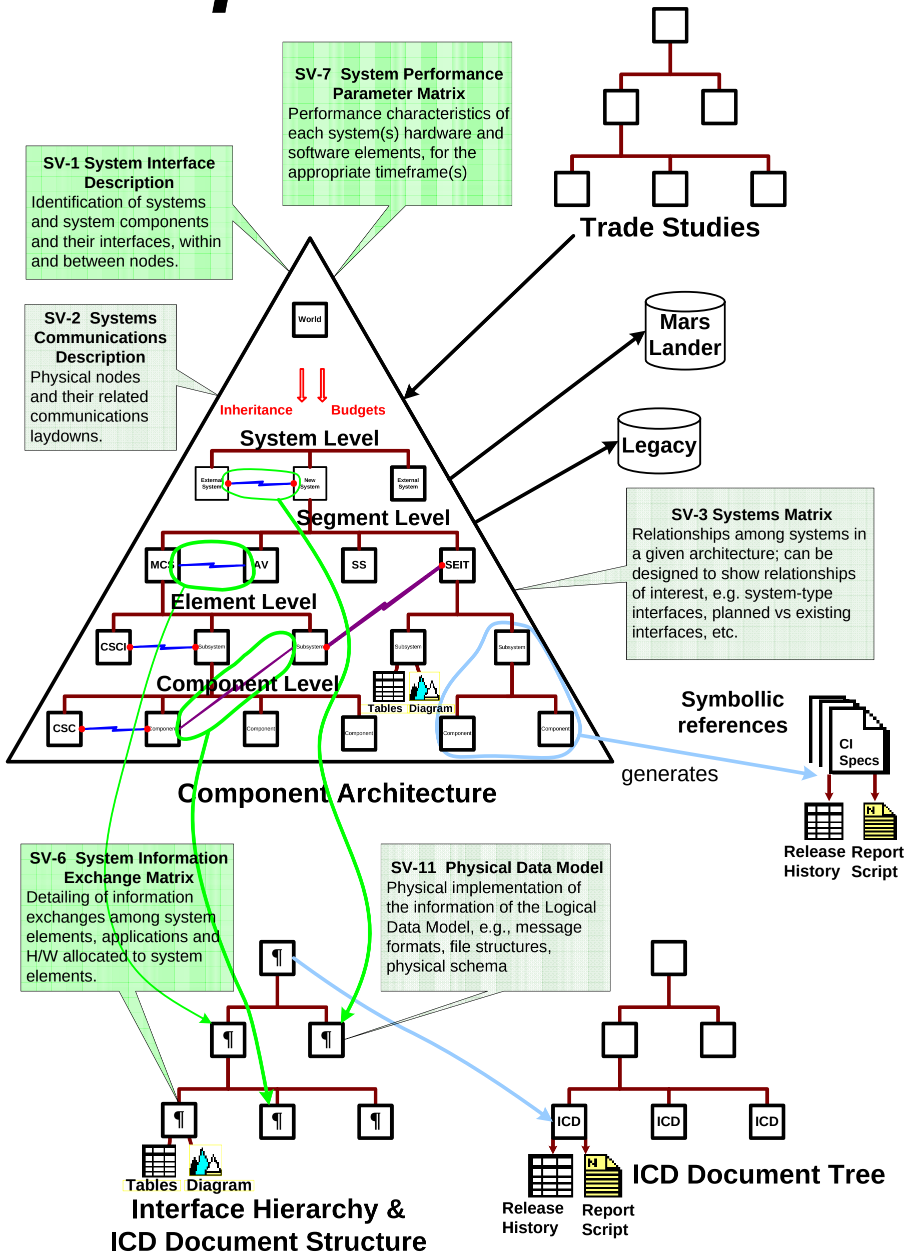


Behavioral Decomposition

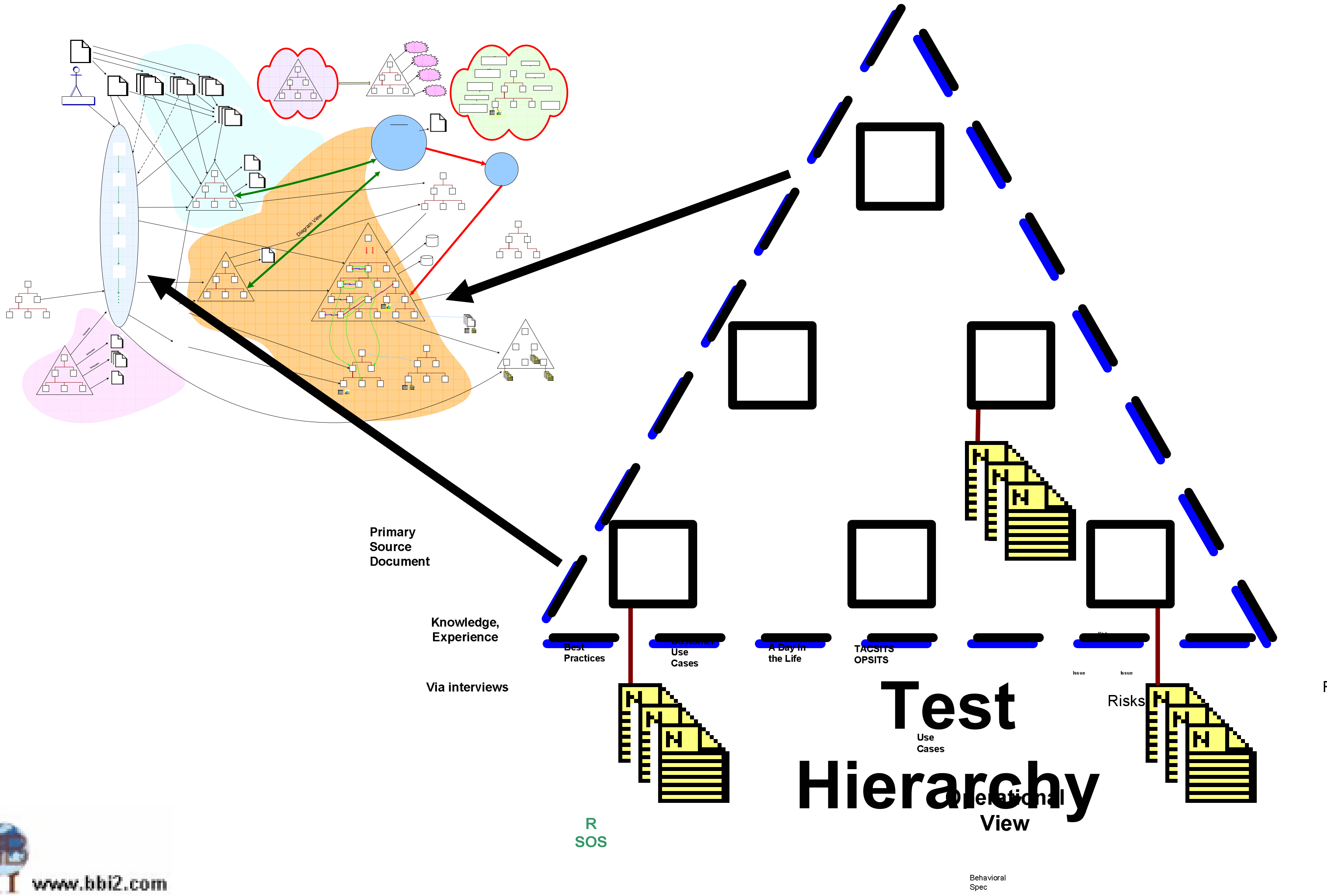
OV-2 Operational Node Connectivity Description
Operational nodes, activities performed at each node, connectivity and information flow between nodes

OV-3 Operational Information Exchange Matrix
Information exchanged between nodes and the relevant attributes of that exchange such as media, quality, quantity, and the level of interoperability required

Component Architecture

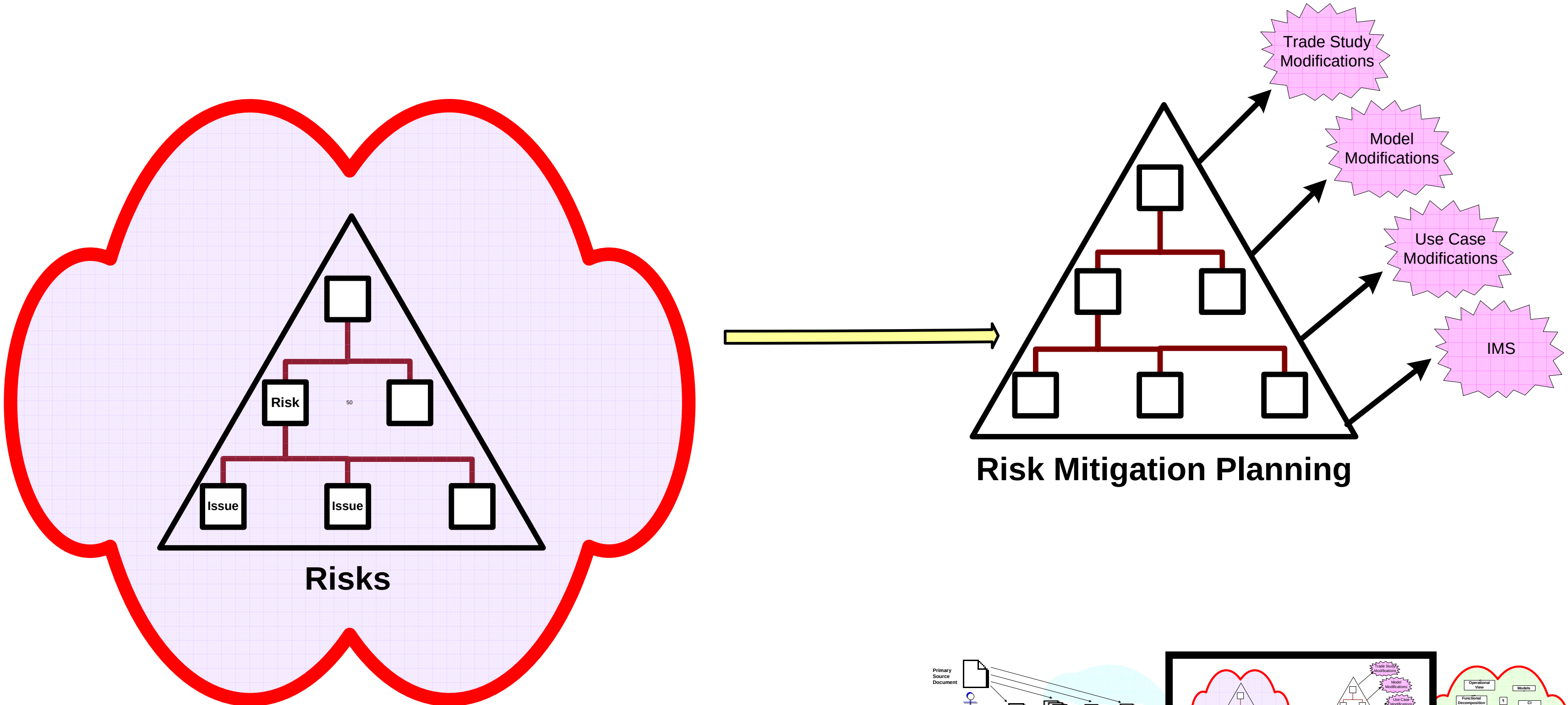


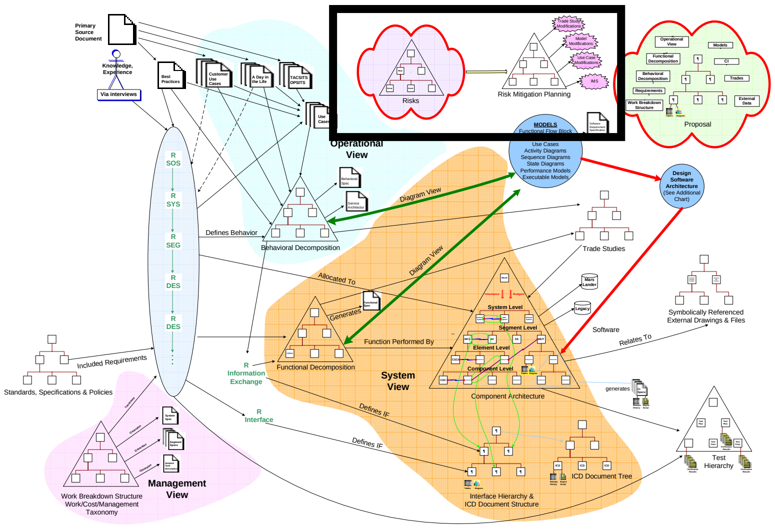
Test



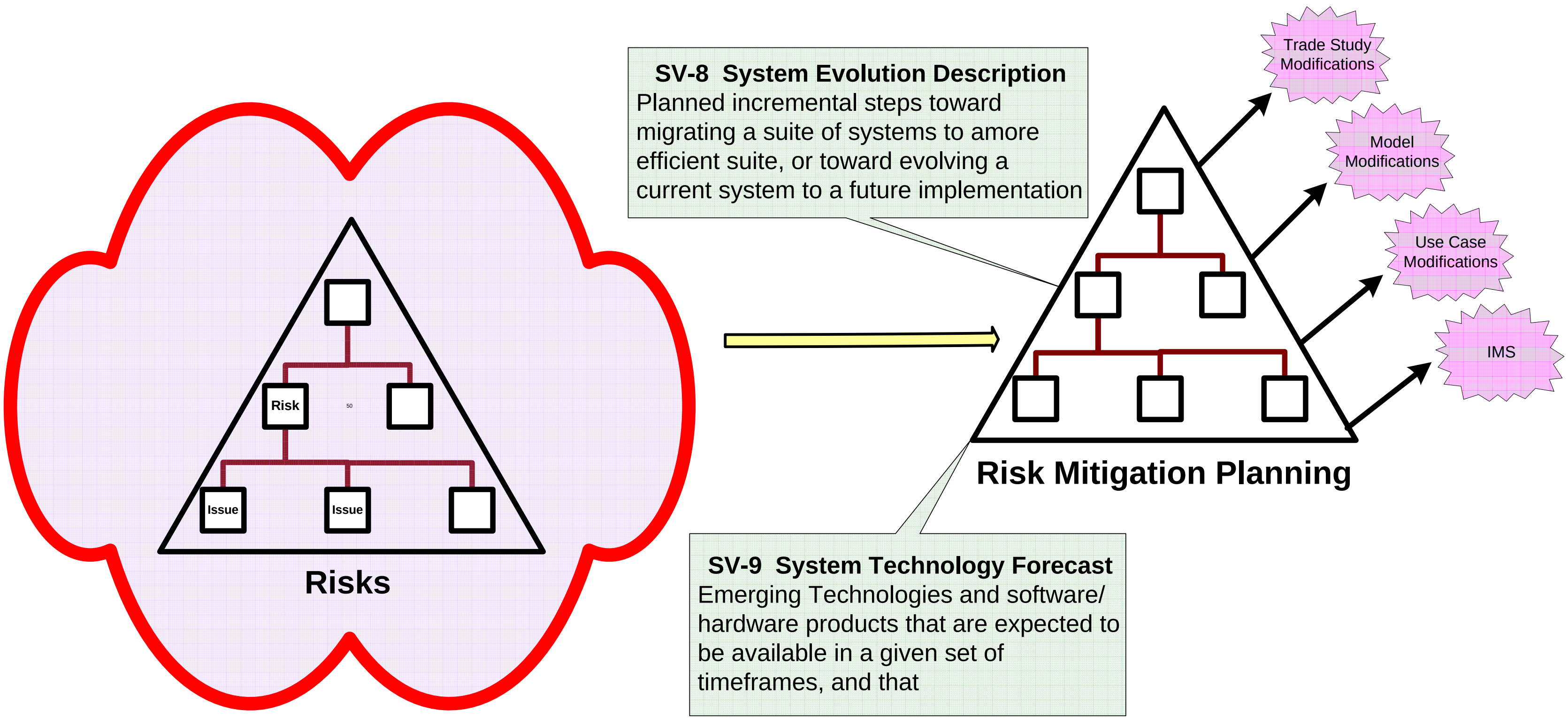
Primary
Source
Document
Knowledge,
Experience
Via interviews
Best
Practices
Use
Cases
A Day In
the Life
TACSITS
OPSITS
Issue
Issue
Risks
Test
Hierarchy
Use
Cases
Operational
View
R
SOS
Behavioral
Spec

Risk


Risk
50
Issue
Issue
Risks
Trade Study Modifications
Model Modifications
Use Case Modifications
IMS
Risk Mitigation Planning

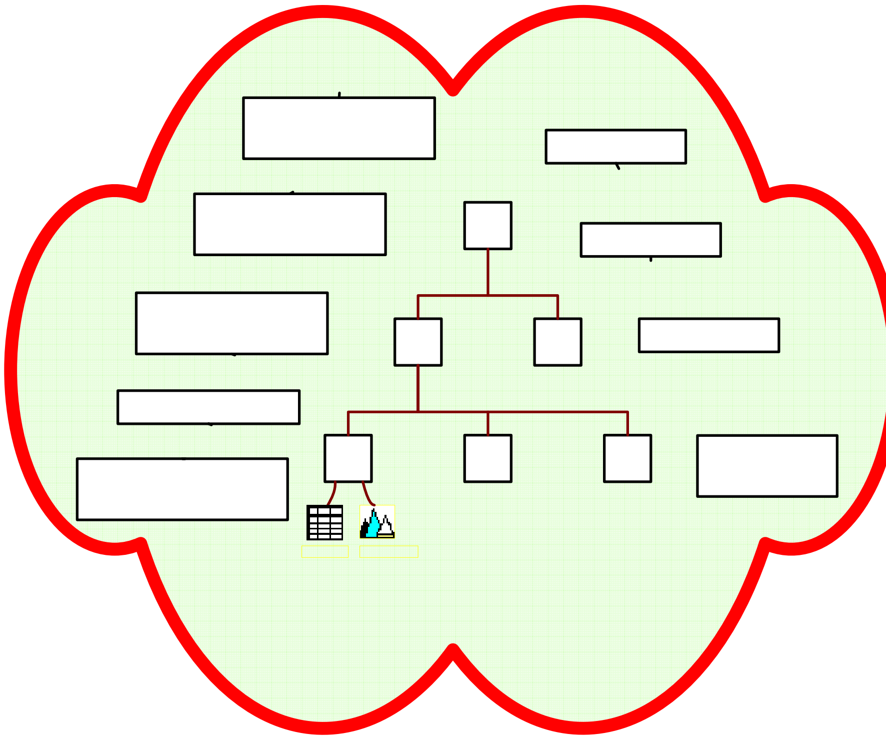


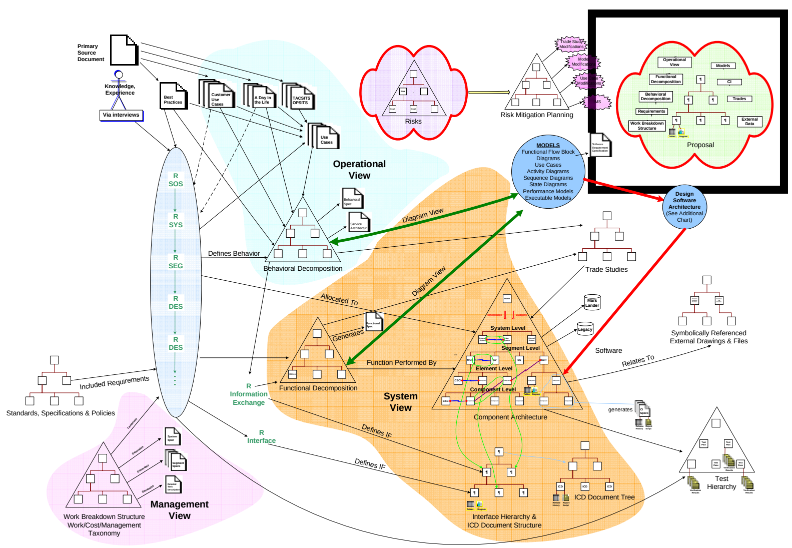
Risk



Risk
Issue
Issue
Risks
SV-8 System Evolution Description
Planned incremental steps toward migrating a suite of systems to amore efficient suite, or toward evolving a current system to a future implementation
Risk Mitigation Planning
Trade Study Modifications
Model Modifications
Use Case Modifications
IMS
SV-9 System Technology Forecast
Emerging Technologies and software/ hardware products that are expected to be available in a given set of timeframes, and that

Proposal





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ICD Document Tree
generates
Test Hierarchy
Work Breakdown Structure Work/Cost/Management Taxonomy
Management View

Keys to Successful Information Model Implementation.

- Reuse of (tailored) tools and models for each deployment
- Understanding the impact of changes on the entire program
- Processes which facilitate innovative changes
- Integrated work environment
- Ability to translate change at one level to changes at all levels within the WBS
- Understanding what needs to happen (Operational Requirements)
- Identification of gaps between operational needs and selected approach
- Value system to support focus on narrowing gaps with most impact
- Infrastructure which encourages and supports alternative approaches which can better satisfy higher level needs
- Infrastructure which supports rapid evaluation of the value and impact of alternative approaches
- Thinking outside the scope of current solutions

Support Structure

- Integrated Information Model to facilitate common understanding and collaborative work environment
- Operational Requirements
  - Operational models
  - Flexibility to restate operational models and capabilities to meet original objectives with alternative approaches
  - Ability to recognize the value of enhanced or new capabilities
- Linkage of operational needs to design requirements
- Operational models
  - Facilitate understanding of needs
  - Organize information
- System and design models
  - Facilitate understanding of system and design
  - Organize information
- Continuous validation
- Measures of Effectivity and a Value System
- Best Practices
- Lessons Learned

Validate Requirements to Satisfy Operational Needs

- Validation is a continuous ongoing process to make sure the right thing is being done
- Capturing Satisfaction Arguments as the analysis, decomposition and design proceeds identifies gaps early at a time they can be more easily resolved
- Measures of effectivity can be integrated with satisfaction arguments
- Formal Validation will tie together elements of the Information Model to validate that the operational needs are satisfied.

Conclusion

An Information Model based approach supports an optimal design enhancing program capabilities. It drives a collaborative work environment reducing rework, revealing issues and supporting needed changes in an efficient manner.

The Information Model approach provides a roadmap for enterprise development through integration of corporate knowledge and experience. It supports the information maturity processes through their integration in elements of daily workflow. It reduces rework in preparation of work products and in the work process.

Models are key to both characterizing System Performance and relating this to the operational needs through the measures of effectivity

November 12-15, 2007

NAVAIR

A Methodology for Assessing and Prioritizing The Risks Associated with The Level of Verification, Validation and Accreditation Of Models And Simulations

Track 5: Virtual Testing / Modeling and Simulation in the Collaborative Environment

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Building 2109
Patuxent River, MD 20670
301-342-4154
James.Elele@Navy.mil

Motivation

- ***Modeling & Simulation (M&S) are integral to the Defense Acquisition process in the United States***
- ***For M&S to be useful tools in acquisition, they must be credible and suitable to the specific intended use(s) of interest***
- ***Verification, Validation and Accreditation (VV&A) helps to reduce risk associated with M&S use by establishing:***
  - **Whether a particular M&S and its input data are credible and suitable for a particular task**
  - **Based on objective evidence**
- ***DoD, Service and Operational Test Agency (OTA) policy require VV&A for M&S used to support acquisition***
  - **DoDI 5000.61, SECNAVINST 5200.40, COTFI 5000.1A**
- ***Resources are limited, so you need a logical way to guide your investment in model credibility and VV&A***
  - **How much effort to expend establishing credibility and suitability of your M&S toolbox (supporting VV&A)**
  - **How best to invest resources to get the most return on investment and add the most value**

M&S and Risk in Policy

- ***All VV&A implementing policies we're aware of indicate that the magnitude of the effort to support accreditation should be commensurate with risk***
  - **DoDI 5000.61, SECNAVINST 5200.40 …**

- ***But --- little practical guidance is given in these high level policies on how to actually do this***

- ***This briefing describes a general approach developed by the Joint Accreditation Support Activity (JASA) to establishing a cost effective risk-based VV&A strategy for acquisition programs:***
  - **Consistent with policy**
  - **Based on experience with successful M&S accreditation efforts**
  - **Consistent with the Defense Modeling and Simulation Office's VV&A Recommended Practices Guide (RPG)**
  - **Incorporating industry standards and best practice**

Our Approach

- **Flexible and Proven Approach** *:*
  - Is consistent with VV&A policy and the Defense Modeling and Simulation Office's VV&A Recommended Practices Guide (RPG)
  - Is based on experience with successful M&S accreditation efforts, supporting major acquisition programs (e.g. PMA-261 CH-53K, VH-71, & P-8A Multi-mission Aircraft program)
  - Reflects industry standards and best practice
  - Incorporates risk-based accreditation methodology developed by Joint Accreditation Support Activity (JASA) over more than a decade
  - Builds on structures and practices already in place in DoD acquisition program (program's existing risk management approach, working group/IPT structure, delegation agreements, etc.)

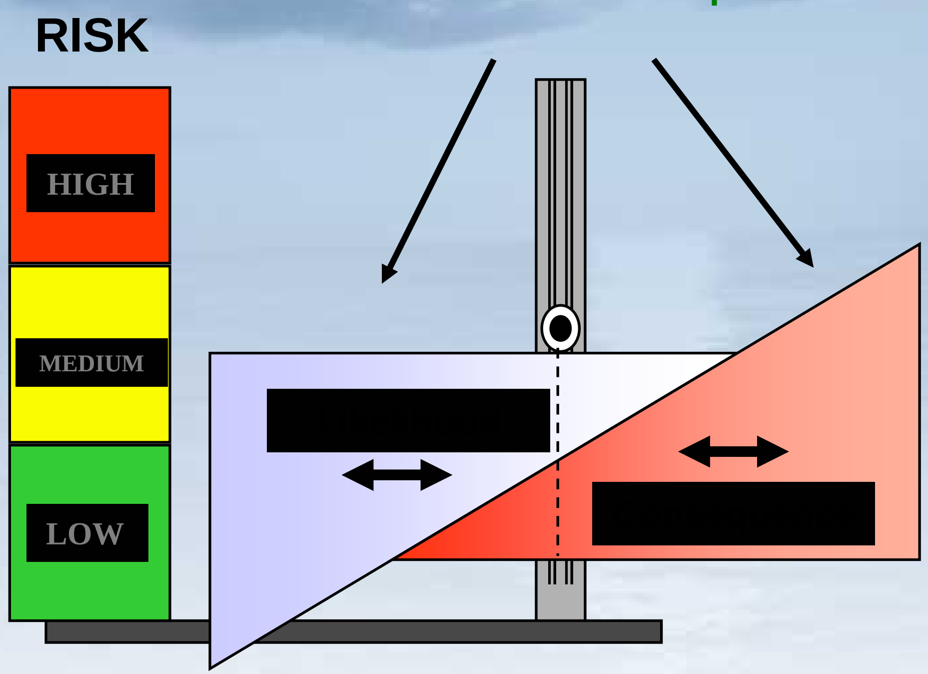
What is Risk?

- *In the risk management community, risk is generally defined as the likelihood that something (usually bad) will happen times the consequences if it does*
  - Sometimes in casual speech people use the word “risk” to mean likelihood of occurrence

- *To reduce risk, either reduce the likelihood that something will occur <ins>or</ins> reduce the severity of the consequence*
  - Risk literature also discusses the idea of exposure, which we’ll come back to shortly

RISK = LIKELIHOOD X CONSEQUENCE

To reduce risk, reduce either likelihood or consequence

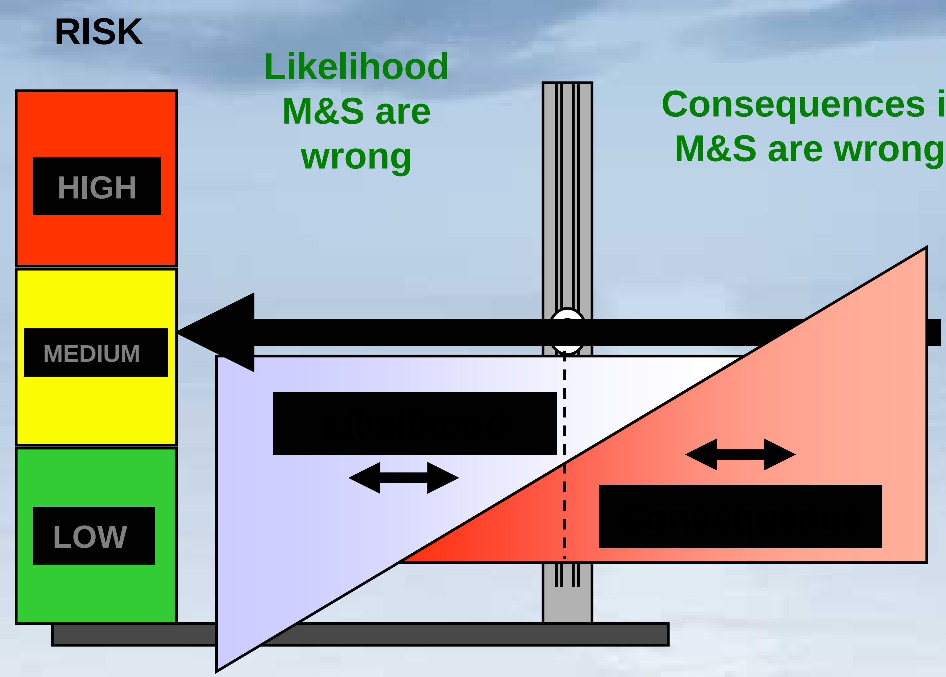


Risk Associated with M&S Use

- ***Here, the risk of interest is the risk associated with using M&S***
  - M&S includes the models and simulations as well as the necessary input data
- ***Likelihood is the odds that the M&S and/or their input data are incorrect or inappropriate to your intended use***
- ***Consequence is the impact if the M&S output is wrong but you believe it and act on it***

Note: The risk associated with model development – will it be done on time and within budget—is an important but separate issue. Here we focus on operational risk.

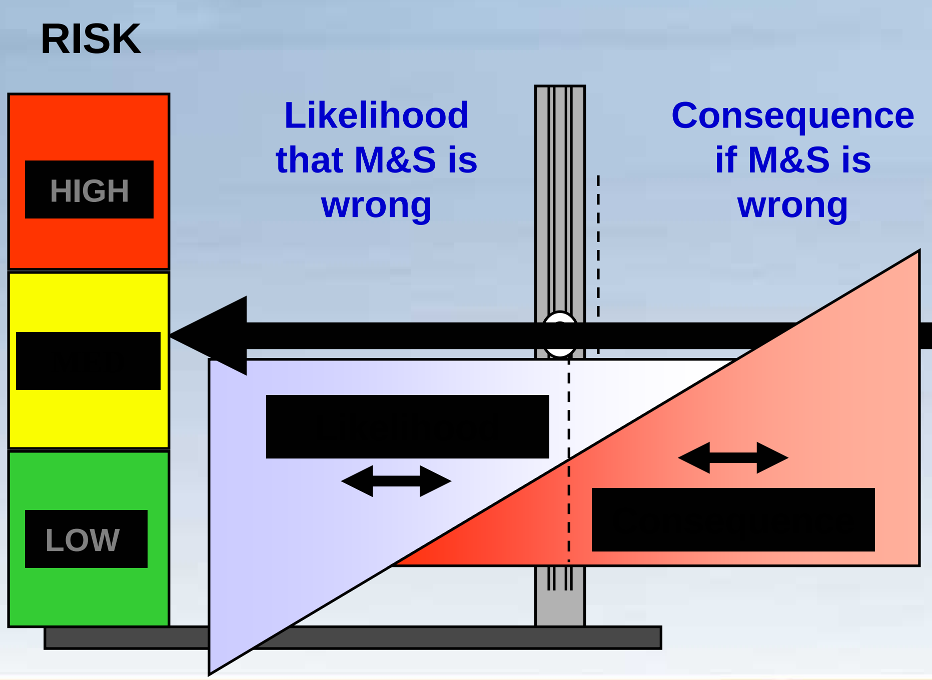
RISK = LIKELIHOOD X CONSEQUENCE



Consequence of a Poor Decision vs. Consequence if Model is Wrong…

- ***Consequence if model is wrong depends on*:**
  - **Role M&S play in the decision-making process**
  - **Consequence of a poor decision**

- ***Here, the role of M&S in decision making is similar to the concept of exposure in the risk literature***
  - **Reduce risk by limiting exposure**
  - **One way to reduce the risk associated with M&S use is by limiting the role of M&S in the decision process**



Consequence if model is wrong =

f (role of M&S in decision

<u>and</u>

consequence of poor decision)

So Here's the Point …

- ***Risk associated with use of M&S is driven by likelihood M&S is wrong and consequence thereof***

- ***VV&A addresses likelihood of M&S error (and thus confidence in model results)***
  - **Level of risk you can accept and consequences if model is wrong drive the amount of effort required to establish an acceptable level of confidence**
  - **Also, likelihood M&S is wrong and consequence if the model is wrong drive risk you accept if you use M&S**

- ***If you had a practical method of apply these principles, you could determine how much effort to put into VV&A***
  - **What kind and how much evidence is required to establish confidence and reach accreditation decision for particular uses**
  - **Extent of appropriate review process**
  - **Level of independence in V&V and review**
  - **Appropriate level of accreditation authority**

Drive Resources

- ***This briefing offers you one approach to consider and some implementation suggestions***

Considerations/Practical Problems

- ***Problem: You can't always (or even often) come up with actual numbers for either consequence (cost, lives lost, etc.) or likelihood, so how can you multiply what you don't have?***

  – ***Solution:***
    - **Usually resort to using estimates within defined bands or levels or bins: High, Medium, Low, etc.**
    - **Adopt a scheme for combining levels to arrive at a single value (combine likelihood value and consequence value to get risk value)**
    - **System Safety community has some practical ideas we'll show you**

- ***Heads up:***
  – **Current DoD and Navy VV&A policy discusses certain circumstances in which formal accreditation of M&S is required (DoD 5000.61, SECNAVINST 5200.40)**
  – **Updated Navy policy will require ALL M&S in use in the Navy as of the effective date of the instruction to be verified, validated and accredited (proposed SECNAVINST 5200.40A)**
  – **Your strategy needs to have provisions in case 5200.40A comes into effect during the life of your program**

Tools of the Trade

- ***You'll need scales and rules***
  - Scale and selection criteria for
    - Levels of risk associated with M&S use
    - Levels of likelihood of error (and an inverse scale for the level of confidence in M&S results)
    - Levels of consequence if model is wrong
    - Levels for role of M&S in decision making
    - Levels of consequence if decision is poor
  - Level combining rules
    - Combine (role of M&S in decision making) & (level of consequence of a poor decision) to get (Level of consequence if model is wrong)
    - Combine (likelihood of model error) & (level of consequence if model is wrong) to get (risk level)

More Tools

- ***And you'll need Tables***
  - **Nature and extent of information necessary to support accreditation as a function of acceptable likelihood of M&S error (or required level of confidence)**
  - **Method of developing accreditation recommendation given level of consequence of M&S error**
  - **Approval/signature authority given level of consequence of M&S error**
- ***The next few slides give a quick trip through the method (scope VV&A effort) and (estimate risk given a decision to use a model as is) to give you a feel for how the tools are used***
- ***Then we'll look at notional samples of each tool***
- ***Then we'll discuss some examples of how these ideas have been used in successful accreditation efforts***

Goal #1: How much VV&A is necessary to support accreditation?

Key: If you know this, you can figure this out

- 1. Define intended use (decision supported by M&S)
- 2. Determine role of M&S in the decision process and pick appropriate value from role table
- 3. Assess consequence if the decision is poor and pick the appropriate value from decision consequence table (Consequence of decision)
- 4. Determine what level of risk the decision maker is willing to assume for this particular use of M&S (Acceptable Risk)
- 5. Use role/decision consequence table to determine a value for consequence if the model is incorrect (Consequence if M&S wrong)
- 6. Use Likelihood of error/decision consequence table to determine the highest likelihood of error value that will result in the acceptable level of risk given the consequence/M&S wrong
- 7. Look at the VV&A evidence table to determine what kind and how much information is necessary to support an accreditation assessment, given the likelihood of error value from step 6.

Goal #1 (continued)

- **8. Look at the Accreditation Recommendation table to determine what approach will be taken to generate an accreditation recommendation, given the consequence-M&S wrong**
- **9. Look at the Decision Authority table to determine the signature authority for VV&A plans and reports as well as the accreditation decision authority.**
- **10. Use answers in 7, 8, and 9 to develop a workable plan to gather/generate required information package, generate an accreditation recommendation, and come to an accreditation decision**

Goal #2: How much risk is associated with M&S use, given the evidence available?

Key: If you know this, you can figure this out

Reality Bites: You have no choice of M&S and you have no time or resources for additional V&V. Here's how to get a handle on the risk associated with model use.

- **You'll need to do some research first**
- **1. Gather the VV&A related information that is available, look at the likelihood of model error table, and determine roughly which level the nature and amount of information you have equates to—this gives you the likelihood of error value**
- **Then you'll need to know some key characteristics about the situation under consideration**
- **2. Define intended use (decision supported by M&S)**
- **3. Determine role of M&S in the decision process and pick appropriate value from role table**
- **4. Assess consequence if the decision is poor and pick the appropriate value from decision consequence table (consequence of poor decision)**

Goal 2 (continued)

Then determine the level of consequence if the model is wrong

- 5. Use the role of M&S level from Step 3 and the consequence of poor decision level from Step 4 to determine the level of consequence if the M&S is wrong from the role/consequence of model error table.

Then you can back out level of assumed risk

- 6. Use likelihood of error/consequence of decision table to back out the level of risk

- Clearly not the ideal situation, but it happens quite frequently.
  - Even if you're stuck using the (less than ideal) tool you have, the boss needs to have a feel for how much confidence to place in the answers
  - Path 2 gives you a way to estimate risk

Scales, Rules and Tables

– Examples

– Some Tips and Advice

Levels of Risk

- Here's an example of a risk scale with three levels
  - Many programs use a three level high/medium/low risk scale
  - Very conducive to the use of stoplight charts

Give strong consideration to starting with the risk level structure already in use on your program and adapting it for use in your VV&A approach

Risk Level	Definition
High	Unacceptable. Major disruption likely. Different approach required. Priority management attention required
Moderate	Some disruption may occur. Different approach may be required. Additional management attention may be needed
Low	Minimum impact. Minimum oversight needed to ensure risk remains low.

Levels of Confidence / Likelihood of M&S Error

- **Here's one suggestion based upon JASA's experience and guidelines in DMSO VV&A RPG**

Include one level for either low or unknown level of confidence so that your approach has a minimal effort option to cover emergency or low consequence situations

Likelihood of Error	Confidence Level	Description
1	4	Very high confidence based upon extensive documented V&V relevant to intended use
2	3	High confidence based on face validation by SMEs
3	2	Moderate confidence based upon previous usage history
4 (High)	1	Low or unknown level of confidence. M&S appears to have the functionality required but credibility is unknown.

Levels of Consequence

- **Here's an extremely simple example of consequence levels with four broadly defined levels**

Whatever scheme you choose, you should make provisions to consider consequences of varying natures including cost, schedule, personnel safety, political, operational

- **Also be sure you take into consideration all of the ways the model output could be wrong (e.g. M&S could erroneous over- or under-estimate performance of a military system, and the consequences might be different for each case)**

Consequence Level	Definition
High	Major disruption to program. Different approach required. Priority management attention and resource allocation required immediately.
Moderately High	Significant disruption to program. Different approach required. Priority management attention required.
Moderate	Noticeable disruption Different approach may be required. Additional management attention may be needed.
Low	Minimum impact. Minimum oversight needed to ensure risk remains low.

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Levels of Consequences if Decision is Poor

Level	Technical Performance	Schedule	Cost
5	Severe degradation in technical performance; cannot meet KPP or key technical/supportability threshold; will jeapardize program success; no workarounds	Cannot meet key program milestones Slip> __ months	Exceed APBA threshold > (10% of budget)
4	Significant degradation in technical performance or major shortfall in supportability; may jeapardize program success; workarounds may not be available or may have negative consequences	Program critical path affected, all schedule float associated with key milestone exhausted Slip< __ months	Budget increase or unit production cost increases <(10% of budget)
3	Moderate reduction in technical performance or supportability with limited impact on program objectives; workarounds available	Minor schedule slip, no impact to key milestones Slip<month(s) of critical path Sub-system slip> __ months(s)	Budget increase or unit production cost increases < (5% of budget)
2	Minor reduction in technical performance or supportability, can be tolerated withlittle or no impact on program; same approach retained	Additional activities required, able to meet key dates Slip< __ months (s)	Budget increase or unit production costs increases <(1% of budget)
1	Minimal or no impact	Minimal or no impact	Minimal or no impact

Here's a Complicated Scheme for "Quantifying" Consequence (Impact) of Poor Decision

From MIL-STD 882C/D on System Safety

Impact Categories	**Impact Level: Catastrophic**	**Impact Level: Critical**	**Impact Level: Marginal**	**Impact Level: Negligible**
Personnel Safety	Death	Severe Injury	Minor Injury	< Minor Injury
Equipment Safety	Major Equip Loss' Broad Scale Major Damage	Small Scale Major Damage	Broad Scale Minor Damage	Small Scale Minor Damage
Environmental Damage	Severe (Chernobyl)	Major (Love Canal)	Minor	Some Trivial
Occupational Illness	Severe & Broad	Severe or Broad	Minor and Small Scale	Minor or Small Scale
Cost	Loss or Program Funds; 100% Cost Growth	Funds Reduction; 50% to 100% Cost Growth	20% to 50% Cost Growth	<20% Cost Growth
Schedule	Slip Reduces DoD Capabilities	Slip Causes Cost Impact	Slip Causes Internal Turmoil	Republish Schedules
Political	Nat'l or Internat'l (Watergate)	Significant (Tailhook)	Embarrassment ($200 Hammer)	Local
Operational	Widespread Add'l Combat Deaths	Limited Add'l Combat Deaths	Moderate Add'l Casualties	Minimal Add'l Casualties

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Role of M&S in Decision Making

- **Here's an example scheme**

Role Level	**Definition**
4	**M&S will be the <u>only method</u> employed to make a decision**
3	**M&S will be the <u>primary method</u>, employed with other non-M&S methods**
2	**M&S will be a <u>secondary method</u>, employed with other non-M&S methods, and will <u>provide significant data unavailable through other means</u>**
1	**M&S will be a <u>supplemental method</u>, employed with other non-M&S methods, and will <u>provide supplemental data already available through other means</u>**

Combination Schemes

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Risk Management Guide for DoD Acquisition

Fifth Edition V2.0 June 2003 Figure B-2

Level	What is the Likelihood the Risk Event will Happen?
E (High)	Near Certainty
D	Highly Likely
C	Likely
B	Unlikely
A	Remote

Likelihood	A	B	C	D	E
E	M	M	H	H	H
D	L	M	M	H	H
C	L	L	M	M	H
B	L	L	L	M	M
A	L	L	L	L	M

Consequence

	Assigned Risk Level
R	**High** – Unacceptable. Major disruption likely. Different approach reqd. Priority mgmt attention reqd.
Y	**Moderate** – Some disruption. Different approach may be reqd. Addl mgmt attention may be needed
G	**Low** – Minimum impact. Minimum oversight needed to ensure risk remains low.

Level	Technical Performance	And/ or	Schedule	And/ or	Cost	And/ or	Impact on Other Teams
A	Minimal or no impact		Minimal or no impact		Minimal or no impact		None
B	Acceptable, some reduction in margin		Additional resources reqd; able to meet need dates		<5%		Some impact
C	Acceptable; significant reduction in margin		Minor slip in key milestones; not able to meet need date		5 – 7%		Moderate impact
D	Acceptable; no remaining margin		Major slip in key milestones or critical path impacted		7-10%		Major impact
E (High)	Unacceptable		Can't achieve key team or major program milestones		>10%		Unacceptable

Program Risk Reporting

Likelihood

Level	Likelihood the Event Will Happen?	Probability of Occurrence
5 (High)	Near Certainty	~90%
4	Highly Likely	~70%
3	Likely	~50%
2	Low Likelihood	~30%
1	Not Likely	~10%

	1	2	3	4	5
5	L	M	H	H	H
4	L	M	M	H	H
3	L	L	M	M	H
2	L	L	L	M	M
1	L	L	L	L	M

Level of Risk:

High, Med, or Low

Consequence

Level	Technical Performance	Schedule	Cost
5 (High)	Severe degradation in technical performance; cannot meet KPP or key technical/supportability threshold; will jeapardize program success; no workarounds available	Cannot meet key program milestones Slip> __ months	Exceed APBA threshold > (10% of budget)
4	Significant degradation in technical performance or major shortfall in supportability; may jeapardize program success; workarounds may not be available or may have negative consequences	Program critical path affected, all schedule float associated with key milestone exhausted Slip< __ months	Budget increase or unit production cost increases <(10% of budget)
3	Moderate reduction in technical performance or supportability with limited impact on program objectives; workarounds available	Minor schedule slip, no impact to key milestones Slip<month(s) of critical path Sub-system slip> __ months(s)	Budget increase or unit production cost increases < (5% of budget)
2	Minor reduction in technical performance or supportability, can be tolerated withlittle or no impact on program; same approach retained	Additional activities required, able to meet key dates Slip< __ months (s)	Budget increase or unit production costs increases <(1% of budget)
1	Minimal or no consequence to technical performance	Minimal or no impact	Minimal or no impact

Sample Method of Generating
Consequence / Evidence
Required to Support Accreditation

Method of Generating Accreditation Recommendation/Consequence if M&S is Wrong

- **This table identifies, for each level of consequence if the M&S is wrong, the method that will be used to come to an accreditation recommendation**

- **Generally, higher levels of consequence merit review and concurrence by major stakeholders (Program Office, DOT&E, OTA, contractor) with support from appropriate technical SMEs**
  - **The higher the consequence, generally the more appearance of some independent review becomes important**
  - **Give strong consideration for a level requiring only the judgment of a qualified analyst or engineer with minimal (but some) documentation requirements**

Consequence Level	Method of Generating Accreditation Recommendation
4 (highest)	Formal Review of Accreditation Case by specially convened Accreditation Review Board resulting in recommendation documented in formal accreditation package
3	Review of accreditation case by M&S IPT resulting in recommendation documented in detailed briefing or report
2	Review of accreditation case by recognized SME resulting in recommendation documented in briefing or report format
1	Review of accreditation case by responsible engineer documented in Memo for the Record

Example Scheme for "Quantifying" Likelihood

An Example Scheme for "Quantifying" Likelihood

****The number of items should be specified**

Likelihood Description	Likelihood of Occurrence over Lifetime of an Item	Likelihood of Occurrence Per Number of Items**
Frequent	Likely to Occur Frequently	Widely Experienced
Probable	Will Occur Several Times in Life of Item	Will Occur Frequently
Occasional	Likely to Occur Some Time in Life of Item	Will Occur Several Times
Remote	Unlikely but Possible to Occur in Life of Item	Unlikely but can Reasonably be Expected to Occur
Improbable	So Unlikely, it can be Assumed Occurrence May Not Be Experienced	Unlikely to Occur but Possible

Evidence Required to Support Accreditation/Likelihood of Error

- *For each level of likelihood of error and confidence level, the table summarizes the information necessary to support an accreditation assessment*
  - More rigorous verification, validation, configuration management, discipline in model development, and oversight and review are required to drive down likelihood of error
  - As likelihood of error goes down, confidence in model results goes up

Likelihood of Error	Confidence Level	Evidence Required to Support Accreditation Assessment
1	4	Level 3 + extensive body of documented verification and validation + evidence of disciplined M&S development including history of technical and managerial review over time
2	3	Level 2 + SME face validation relevant to current intended use + evidence of effective configuration management
3	2	Level 1 + usage history + known V&V history
4 (High)	1	Comparison of M&S requirement derived from intended use with capabilities and limitations of candidate simulation

This is based on JASA's rules of thumb adopted by the DMSO VV&A RPG. See "Role of Accreditation Agent in VV&A of Legacy Simulations" for more details. www.vva.dmso.mil

Decision Authority/
Consequence if the Model is Wrong

- *This table identifies, for each consequence (M&S wrong) level, the signature authority for VV&A plans and reports as well as the accreditation decision authority*
- *Generally, delegating the signature and decision authority as low as seems reasonable is the most efficient use of resources*
  - DoD and Service policy give OTAs accreditation authority for use of M&S in OT&E; PM for SUT must submit accreditation package and make recommendation
  - Current practice is for PM to be AA for uses of M&S within the purview of the program office (e.g. DT&E including demonstration of spec compliance, LFT&E)

Consequence Level	Signature Authority VV&A Plans & Rpts	Decision Authority M&S Accreditation
4 (highest)	Acquisition Program Manager (For use of M&S in OT&E, PM is signature authority with OTA's concurrence)	Acquisition Program Manager (For use of M&S in OT&E, OTA is decision authority with recommendation from PM)
3	Chief Engineer	Chief Engineer
2	Chair, M&S IPT	Chair, M&S IPT
1	Responsible Engineer or Analyst	Responsible Engineer or Analyst

Criticality Analysis: Importance of Decisions

- *Descriptions of Level of Importance of Decision*

Level	Description
4	Intended use addresses multiple areas of significant program risk, key program reviews and test events, key system performance analysis, primary test objectives and test article design, system requirements definition, and/or high software criticality, used to make a technical or managerial decision
3	Intended use addresses an area of significant program risk …
2	Intended use addresses medium or low program risk, other program reviews and test events, secondary test objectives and test article design, other system requirements and system performance analysis, and medium or low S/W criticality used to make technical or managerial decisions
1	1 = Intended use addresses program objectives or analysis that is not a significant factor in the technical or managerial decision making process

Criticality Analysis: Role of M&S

- *Here's an example scheme*

Role Level	Definition
4	**M&S will be the <u>only method</u> employed to make a decision**
3	**M&S will be the <u>primary method</u>, employed with other non-M&S methods**
2	**M&S will be a <u>secondary method</u>, employed with other non-M&S methods, and will <u>provide significant data unavailable through other means</u>**
1	**M&S will be a <u>supplemental method</u>, employed with other non-M&S methods, and will <u>provide supplemental data already available through other means</u>**

Criticality Measure

- ***Criticality Measure is determined from level of reliance on M&S and importance of the decision***
- ***Criticality Measure drives nature and amount of information and effort applied to VV&A of this model***

Importance of Decisions	Level of Reliance on M&S			
	4	3	2	1
4	4	4 or 3	3 or 2	2
3	3	3	2	2 or 1
2	2	2	2	1
1	1	1	1	1

Resources Applied to VV&A

Criticality

Source: DD(X) Verification, Validation and Accreditation Overview by Charles Hays of Northrup Grumman Corporation. Presented at NMSO VV&A TWG, Salt Lake City UT on 16 Feb 2005

Benefit of the risk-based VV&A strategy

- ***Helps you develop a standard operating procedure for scoping and carrying out VV&A efforts on your program so that day to day implementation is consistent, effective, efficient, and straightforward***
  - **Upper management can dictate deviations at their discretion so long as the deviations and the rationale are documented**
  - **Helps you devise a mechanism for elevating particular M&S uses to “command interest” status for funding and risk mitigation**

- ***In the early stages of your program, our VV&A approach will help you scope and plan your VV&A strategy over the life of the program***
  - **Get VV&A related activities in contracts, schedules, budgets, resource planning**

- ***As the program progresses, an established strategy gives you a way to quickly scope the effort necessary to determine the credibility of M&S for unanticipated uses as the program evolves***

You can work out a thoughtful VV&A strategy early on, or duke it out on a case by case basis each time the issue of accreditation or credibility comes up.

Why not think hard early on in the program, and then get on with it?

Applying Resources Intelligently

- ***Other Acquisition programs have used the practical methods:***
  - **To determine how much effort to put into VV&A and**
  - **To get the most return on their investment**

- ***This method offers you an approach for figuring out:***
  - **What kind and how much evidence is required to establish a particular level of confidence**
  - **What kind and how much evidence is required to reach accreditation decision for particular uses**
  - **The appropriate level of review to generate an accreditation recommendation**
  - **The appropriate level of independence in V&V and review**
  - **The appropriate level of signature authority for VV&A plans and reports**
  - **The appropriate level for accreditation authority**

All of these factors drive resources

Some Practical Help with Risk Assessment

- ***System Safety community within DoD and foreign defense establishments have grappled with risk assessment***
  - **Defining qualitative levels of impact in many areas (financial loss, political embarrassment, material loss, personnel loss, etc.)**
  - **Defining qualitative levels of risk given likelihood and consequence**
  - **See MIL STD 882D for examples**

- ***JASA and many other groups have a strong interest in VV&A as risk reduction and have contributed to the literature***
  - **JASA's Risk Assessment Example, based upon work we've done for a major acquisition program, is an extreme example, but may also give you some food for thought on doing risk assessment related to model use**
  - **See the DMSO VV&A RPG's core document "Accreditation Agent Role in VV&A of Legacy Models" for JASA's rules of thumb for what kind of and how much information is appropriate to support accreditation assessments given varying levels of acceptable risk**
    - **Download from DMSO's VV&A site: www.vva.dmso.mil**

Questions?

Backup Material

Another Twist

- ***What if the question is which tools to place emphasis on over the life of the program?***

- ***Criticality measure is one idea***
  - **Takes into account role of M&S in making decisions and**
  - **Number and importance of decisions that M&S is expected to support over the life of the program**

  - **Focus your efforts on those M&S that will be used most often for the highest profile/highest consequence decisions**

Criticality Analysis

- ***An aid for tackling how to best allocate VV&A resources over the life of an acquisition program***
- ***Offered by the Northrop Grumman team working with the DD(X) program: M&S criticality analysis***
  - **Criticality is a function of the dependence on M&S in making decisions over the life of the program, and the nature and importance of those decisions**
  - **The scales used by the NG team are shown on the next two slides**
- ***The idea is that the criticality score for a particular model can help determine whether formal VV&A is required and how much effort will be put into supporting accreditation***
- ***Interesting idea that is intuitively appealing***
- ***One practical implementation issue is the fact that the role of M&S may differ in various phases of the program and in different decisions, so you might need a weighted average or something***

Implementation Suggestions

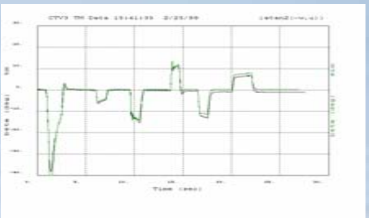
- ***Consider appointing someone to work out a straw man based upon the structure and processes in place in your program***
  - **VV&A person working in conjunction with program person works well**
- ***Present straw man to M&S WG for feedback – rework incorporating feedback then present to MSWG for concurrence***
- ***Once you have concurrence of MSWG, staff it up the chain for management approval***
- ***Get going with implementation once you've got a solid draft or you'll spend the entire program arguing about the nitnoids***

VV&A is Risk Reduction

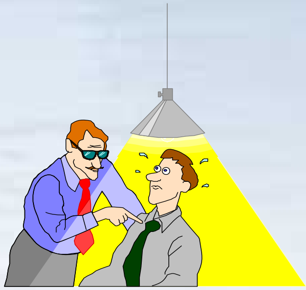
Reduce Likelihood of Error ⇒ Reduce Risk

- ***VERIFICATION***
  - Reduces the likelihood that the software you build (or use) has undetected errors that are fatal to your intended use
  - Reduces the likelihood that the data are inappropriate for the intended application or improperly prepared

- ***VALIDATION***
  - Reduces the likelihood that simulation outputs won’t match the “real world” well enough for you to use them credibly as part of the solution to your problem
  - Reduces the likelihood that the data don’t represent the real world with sufficient accuracy for the application



- ***ACCREDITATION***
  - Reduces the likelihood that an inappropriate or unsuitable simulation is selected for use in solving your problem



What's a JASA
Accreditation Support Package (ASP)?

- ***A JASA ASP (as in A-S-P, not the name of the snake) is an organized way to document and relay the information <u>about a model or simulation and its input data</u> that is typically used to support an accreditation assessment***
  - **Contents are based on the model-related information elements that DoD and Service level policies either require or recommend to support accreditation decisions and 13 years of experience doing accreditation support for DoD acquisition programs**

- ***It has a single volume format organized around the three pillars of M&S credibility conceived by JASA and adopted by the Defense Modeling and Simulation Office (DMSO)***
  - **Capability: Does the simulation do what you want it to?**
  - **Accuracy: How much confidence can be placed in the accuracy of model results?**
  - **Usability: Is there enough information/help available to enable proper, consistent use of the model and correct interpretation of results?**

JASA Accreditation Support Package (ASP) Structure 2004 Specification

1.0 Introduction

Overview of Accreditation Process
Information Needed for Accreditation
- Capability
- Accuracy
- Usability

2.0 Capability

- Model Description
- Functional Capabilities
- Development History
- Summary of Assumptions and Limitations
- Implications for Model Use

See Accreditation Support Package (ASP) Specification, Joint Accreditation Support Activity, September 2004, Rev B May 2005, JASPO-03-M-002B

3.0 Accuracy

Software Accuracy
- S/W Verification Results
- S/W Development and CM Environment
- S/W Quality Assessment

Data Accuracy
- Simulation Data including Pedigree
- Data Transformations

Output Accuracy
- Sensitivity Analysis
- Benchmarking
- Face Validation
- Results Validation

Implications for Model Use

4.0 Usability

- Documentation
- User Support
- Usage History
- Implications for Model Use

JASA's Evolution

- ***Predecessor was the OSD-sponsored Susceptibility Model Assessment and Range Test (SMART) Program***
  - **Five years (FY92-96, OSD-funded, Tri-Service Steering Group)**
  - **Developed and documented cost effective VV&A process for survivability M&S including Accreditation Support Package (ASP) specification**
  - **Exercised process on 5 survivability models**
  - **Documented processes and lessons learned**
- ***JASA was created in FY96 to provide M&S accreditation support services to the <u>larger acquisition community</u>***
  - **Concepts and processes broadly applicable to M&S used in the larger acquisition community, not only for survivability**
  - **Initially under the auspices of the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS), who provided some infrastructure funding from FY96-98 to assist in transition**
  - **FY99 to present almost entirely customer funded with some specific tasking for JTCG/AS (now JASPO)**
  - **2006 JASA became part of the Battlespace Simulation & Test Dept (5.4) NAVAIR**

Terminology: Industry Standards vs. M&S VV&A Policy

Question	SE/SysE/CMMI/ISO 9000 Terminology	M&S VV&A Terminology
Does the product meet the requirements/specs?	**Product Verification**	**M&S Verification and Validation** ***M&S Validation deals with accuracy requirements***
Is the product fit for purpose in the customer's intended environment?	**Product Validation**	**M&S Accreditation** ***Accreditation is a government decision***
What is the desired end state?	**•Acceptance by customer and payment for services** **•Launch of quality product or service**	**Use of M&S by decision maker with an acceptable level of risk**

•Note: CMMI and ISO 9000 emphasize effective process rather than product, but use of terms is consistent with that of the Software Engineering (SE) and Systems Engineering (SysE) communities

MORE ADVANCED COMBINATION SCHEMES

- **Useful when Different Schemes Result In Different Risk Level Ratings**

METHODOLOGY: (see next 4 slides)

1.Use Chart #1 in the “Standard Risk Chart” to determine appropriate color: G1, Y1 or R1

2 2.Use Chart #2 in the “Standard Risk Chart” to determine appropriate color: G2, Y2 or R2

3. 3. Use COMBINED RISK CHART to determine appropriate color: Green, Yellow or Red.

- **NOTE: If you are a decision maker who is more interested in very low risk (i.e. a Risk Averse Decision-maker), use the COMBINED RISK AVERSE CHART instead of the COMBINED RISK CHART**

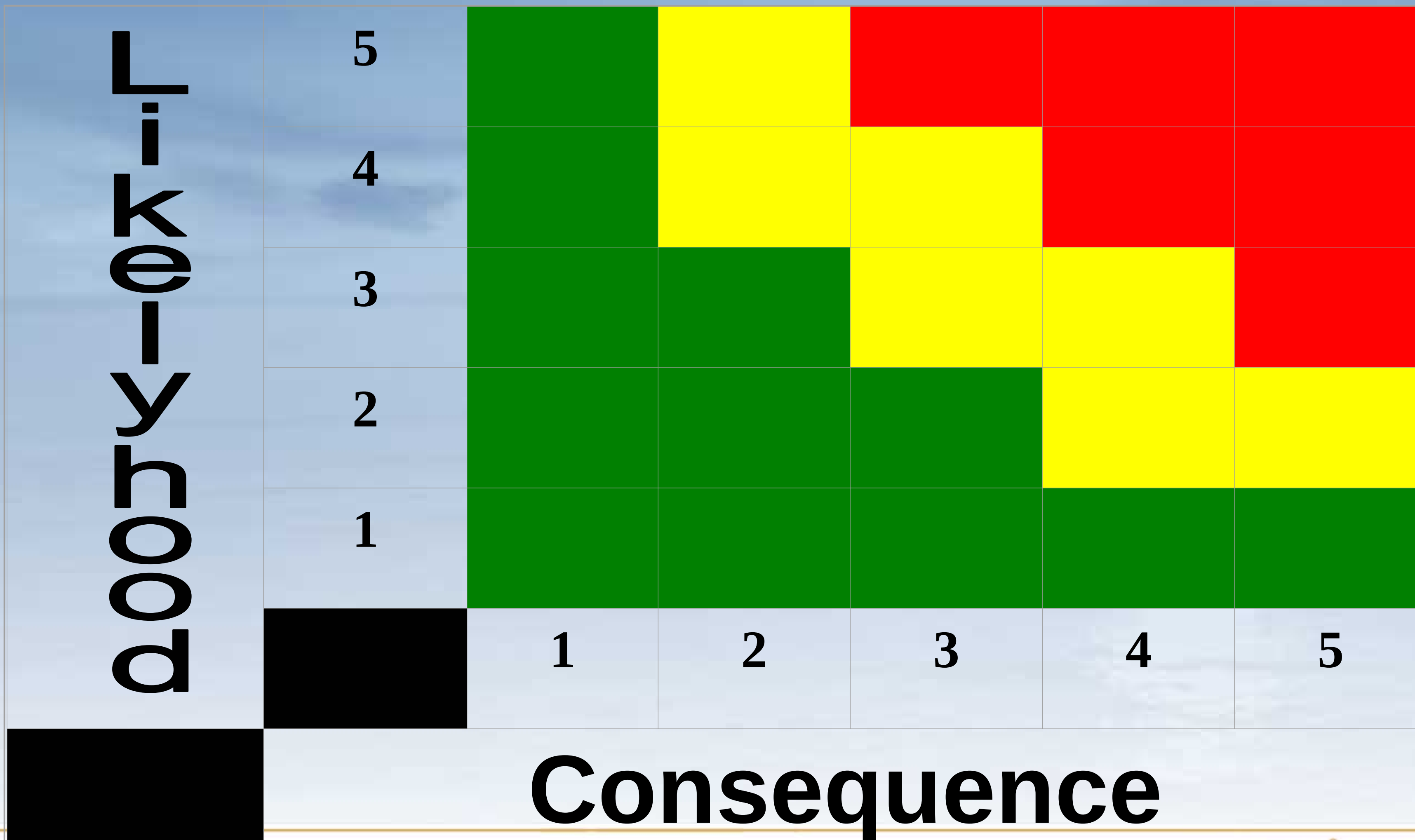
SAMPLE IMPACT TABLE

IMPACT MATRIX			
IMPACT	LEVEL OF RELIANCE		
	3	2	1
CATASTROPHIC	5	4	3
CRITICAL	4	3	2
MARGINAL	3	2	1

SAMPLE CONSEQUENCE TABLE

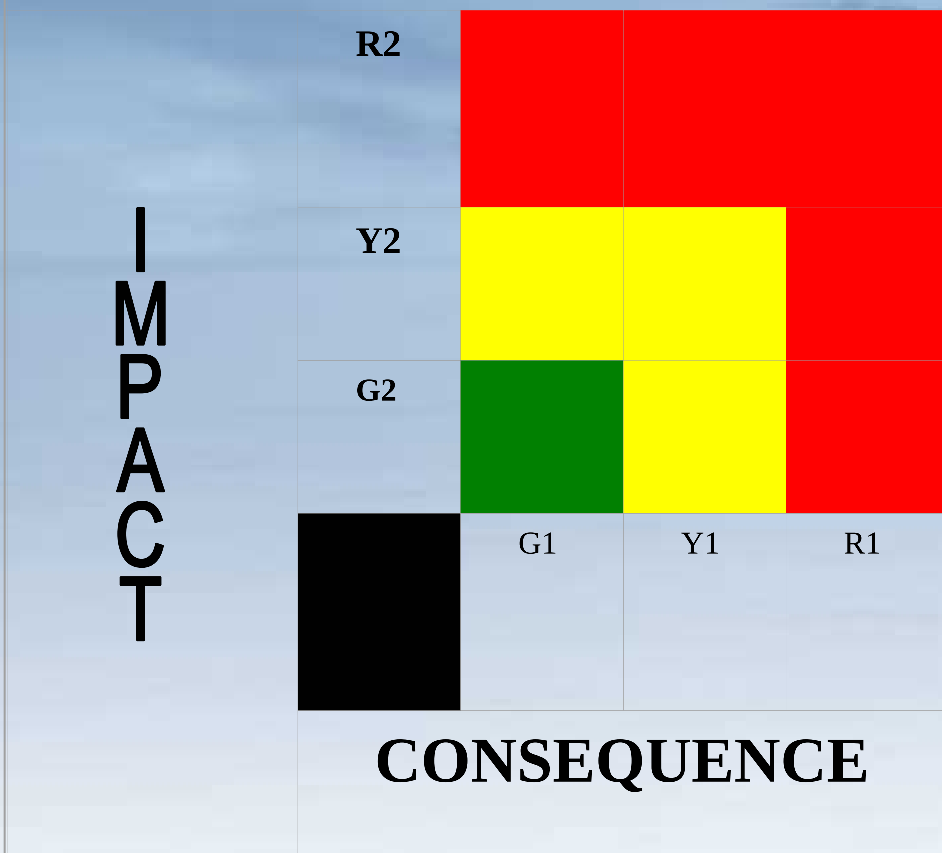
Consequence Matrix			
Importance of Decision	Level of Reliance		
	3	2	1
3	5	4	3
2	4	3	2
1	3	2	1

STANDARD RISK CHART

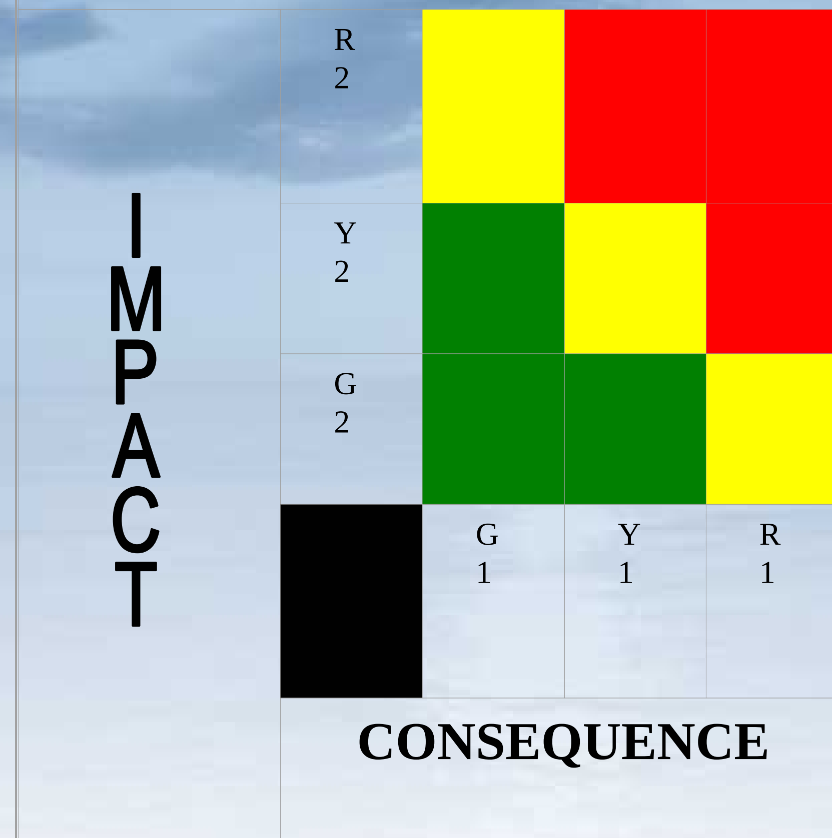


COMBINED RISK CHARTS

RISK AVERSE MATRIX



NORMAL RISK MATRIX



National Defense Industrial Association
10th Annual
Systems Engineering Conference
Track 5 M&S Session 3B5
10:15 am - 12:00 pm

Standardized Documentation for Verification, Validation, and Accreditation - A Status Report to the Systems Engineering Community

Presented by
DoD M&S Project (DMSP)
Project Management Team (PMT)
October 24, 2007

Outline

- Introduction
- Background
- DoD M&S Project
- Concept of Operations
- Policy, Guidance & Standards
- DoD VV&A Documentation Tool
- Structured VV&A Data
- Summary

A Word from Our Sponsor

"Because M&S is a fundamental and essential tool for acquisition programs, planning for use of M&S throughout developmental test and evaluation must be an early consideration in test planning. Just as **M&S planning should be integral to** program acquisition plans and **systems engineering plans**, it should also be integral to the program Test and Evaluation Strategy and T&E Master Plan. **Important planning considerations include**: the use and reuse of M&S applications and data for T&E across the program lifecycle, **establishing credibility of M&S tools and data**, using M&S to predict live test results, and using live test results to improve the credibility of M&S."

Chris DiPetto, Deputy Director
OUSD(AT&L)A&T/SSE/DT&E
March 26, 2007

Introduction

- Modeling and Simulation (M&S) is a key enabler in the acquisition process for systems engineers.
- Using M&S that provide credible results is crucial to fielding defense weapon systems to the warfighter.
- Credibility and confidence in the use of M&S results are achieved through implementation of Verification, Validation, and Accreditation (VV&A) processes.
- VV&A is critical for ensuring M&S is correct, is used correctly, and can produce results a systems engineer can trust.

DoD Directive 5000.59

- DoD Directive 5000.59, DoD M&S Management, 8 Aug 2007
- Sec 4.3: It is DoD policy that M&S management shall ... pursue common and cross-cutting M&S tools, data, and services to achieve DoD's goals
- Sec 5.1.3.5: The M&S SC shall … Oversee … the implementation of best practices of how models and simulations are effectively acquired, developed, managed, and used by DoD Components (e.g., verification, validation, and accreditation; standards; and protocols).

Department of Defense

DIRECTIVE

NUMBER 5000.59
August 8, 2007

USD(AT&L)

SUBJECT: DoD Modeling and Simulation (M&S) Management

References: (a) DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994 (hereby canceled)
(b) Program Decision Memorandum (PDM), December 14, 2005[1]
(c) DoD Directive 5105.18, "DoD Committee Management Program," February 8, 1999
(d) DoD 5000.59-M, "DoD Modeling and Simulation (M&S) Glossary," January 1998
(e) through (j), see Enclosure 1

1. REISSUANCE AND PURPOSE

This Directive:

1.1. Reissues Reference (a) to update policy and responsibilities for DoD M&S management, per Reference (b).

1.2. Establishes the DoD M&S Steering Committee (M&S SC) under the provisions of Reference (c).

1.3. Authorizes the development of DoD Publications as needed and continues to authorize Reference (d), consistent with DoD 5025.1-M (Reference (e)).

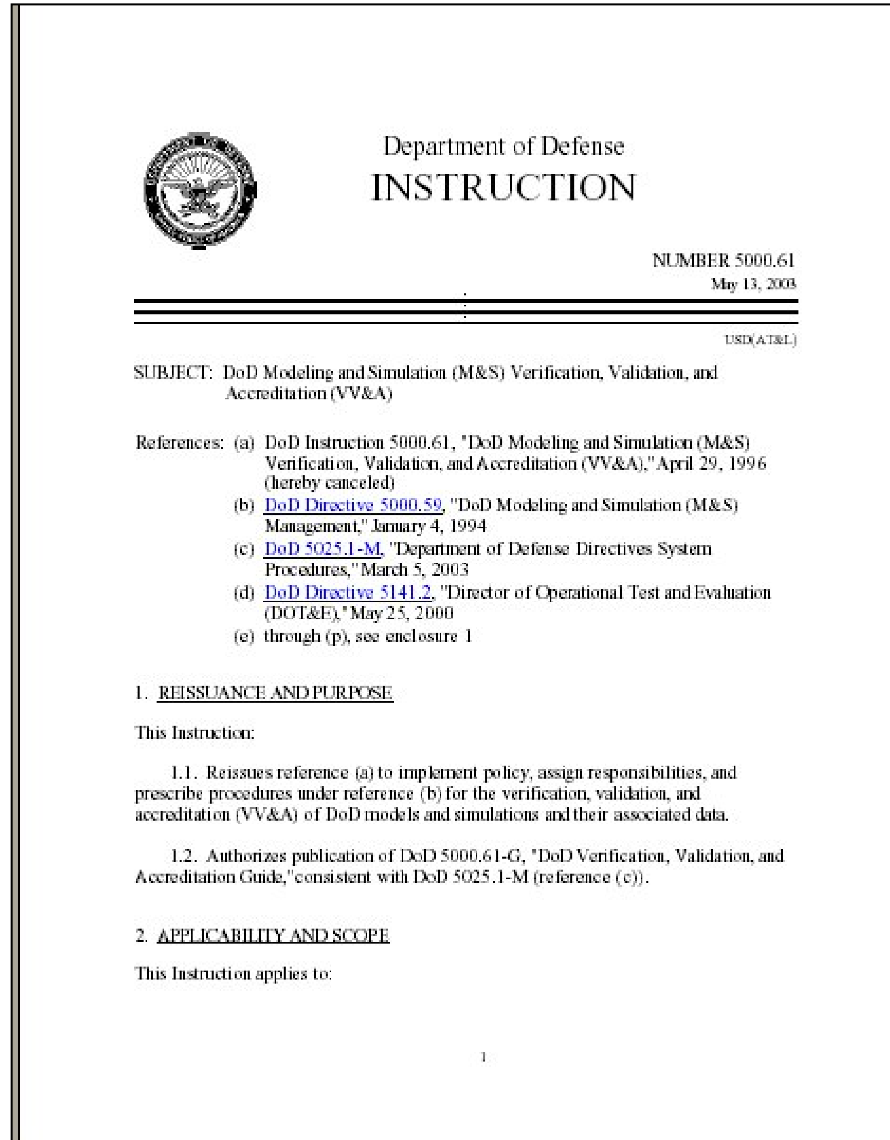
2. APPLICABILITY

2.1. This Directive applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the Department of Defense (hereafter referred to collectively as the "DoD Components").

[1] Available from the Director, Program Analysis and Evaluation

DoD Instruction 5000.61

- DoD Instruction 5000.61, DoD M&S VV&A, 13 May 2003
- Sec 4.1: It is DoD policy that ... Models and simulations used to support major DoD decision-making organizations and processes ... shall be accredited for that specific purpose
- Sec 6.4: VV&A information shall be documented



Department of Defense
INSTRUCTION

NUMBER 5000.61
May 13, 2003

USD(AT&L)

SUBJECT: DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)

References: (a) DoD Instruction 5000.61, "DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)," April 29, 1996 (hereby canceled)
(b) DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994
(c) DoD 5025.1-M, "Department of Defense Directives System Procedures," March 5, 2003
(d) DoD Directive 5141.2, "Director of Operational Test and Evaluation (DOT&E)," May 25, 2000
(e) through (p), see enclosure 1

1. REISSUANCE AND PURPOSE

This Instruction:

1.1. Reissues reference (a) to implement policy, assign responsibilities, and prescribe procedures under reference (b) for the verification, validation, and accreditation (VV&A) of DoD models and simulations and their associated data.

1.2. Authorizes publication of DoD 5000.61-G, "DoD Verification, Validation, and Accreditation Guide," consistent with DoD 5025.1-M (reference (c)).

2. APPLICABILITY AND SCOPE

This Instruction applies to:

Need

- Since 1996 organizations DoD-wide have been implementing VV&A processes and capturing VV&A information
- Plethora of DoD-, Service-, and organization-level documentation guidance
  - No consistency in formats and content descriptions
- No easy method to identify published VV&A information

Importance of VV&A Information

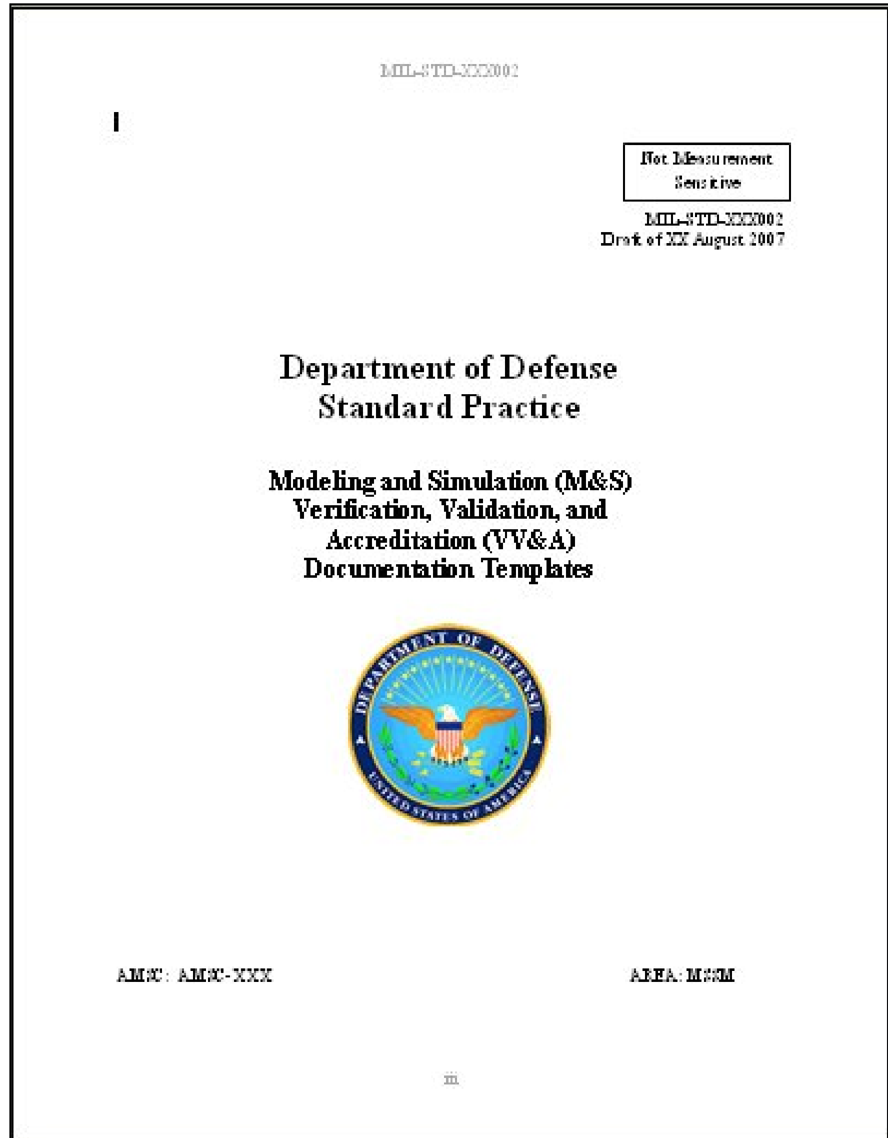
- Documenting VV&A information consistently across DoD yields many returns including the capability to share that information with future users of M&S.
- VV&A information tells a potential user about
  - M&S assumptions (simplifications and potential failure points)
  - M&S capabilities (what the M&S can be used to do)
  - M&S limitations (what it should not be used to do)
- VV&A information saves potential users time and money finding an M&S that satisfies or partially satisfies their needs to use M&S.

Background

- In 2005, a DoD-sponsored Tri-Service VV&A Templates Tiger Team developed templates for four core VV&A documents:
  - Accreditation Plan
  - V&V Plan
  - V&V Report
  - Accreditation Report
- Purpose was to enable expanded M&S reuse by building foundation for consistent V&V information to support accreditation decisions.
- Templates resulted in draft DoD Standard Practice
  - M&S VV&A Documentation Templates (MIL-STD-XXX002)
  - provides common framework for sharing information throughout VV&A processes
  - using templates helps users better understand if M&S can meet their needs
  - templates make it easy to know
    - what kind of information is available
    - where to look in the document for that information
- Templates automated by DoD VV&A Documentation Tool (DVDT)

MIL-STD-XXX002 (draft)

- MIL-STD-XXX002 (draft) DoD Standard Practice “M&S VV&A Documentation Templates”
- Specifies procedures on documenting information obtained through implementing the VV&A processes for M&S when their outputs will be used to supplement decision making in DoD.
- May be cited as solicitation requirements.
- Guidance should be applied in accordance with the scope of the specific purpose for using M&S.


MIL-STD-XXX002

Not Measurement Sensitive

MIL-STD-XXX002
Draft of XX August 2007

Department of Defense
Standard Practice

Modeling and Simulation (M&S)
Verification, Validation, and
Accreditation (VV&A)
Documentation Templates

AMSC: AMSC-XXX

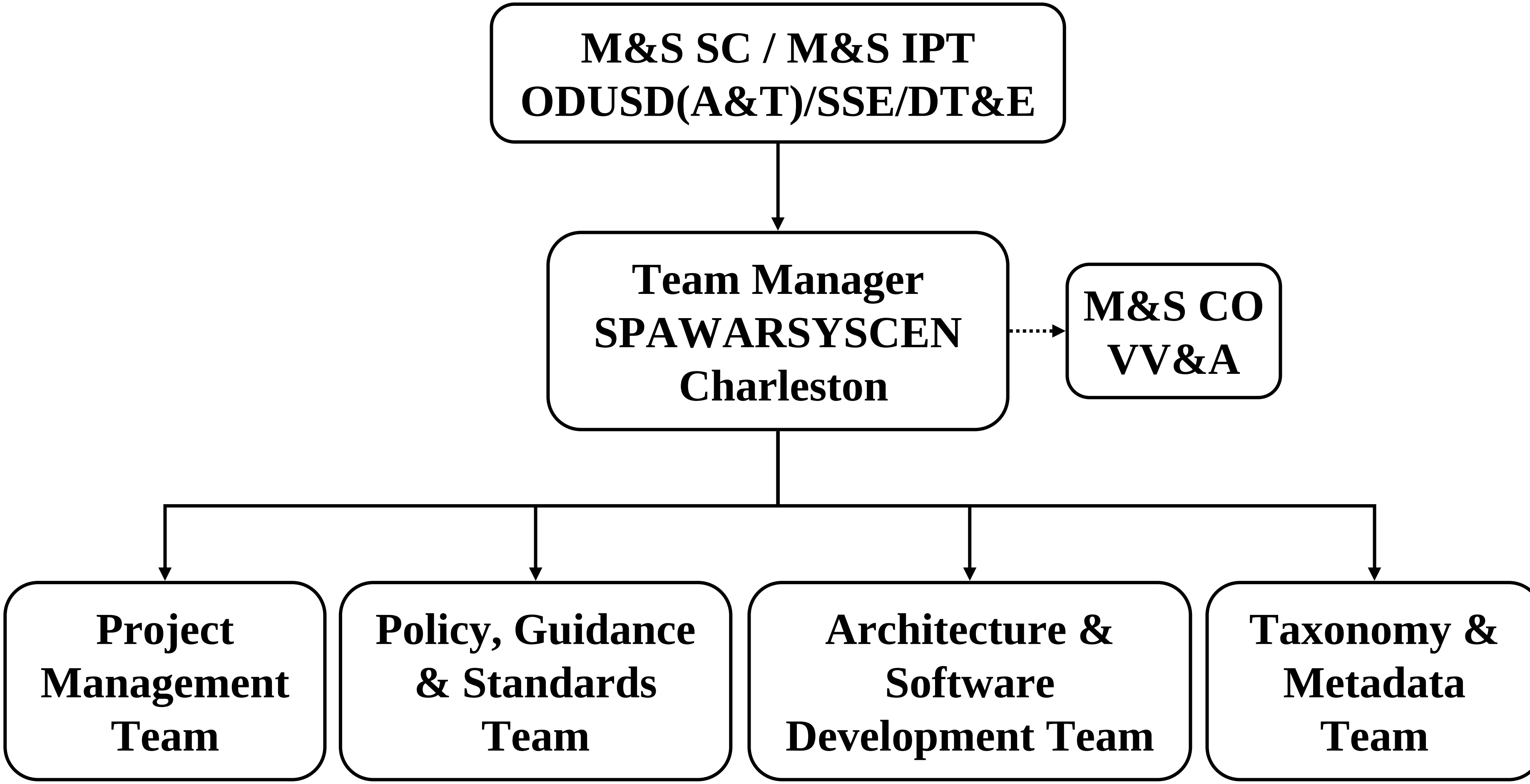
AREA: MSSM

iii

DoD M&S Project

- Sponsor: Department of Defense (DoD) M&S Steering Committee (M&S SC)
- Oversight: Acquisition Community Lead
- Project title: Standardized Documentation for VV&A

Project Management Structure



Project Scope

- Three major tasks and associated deliverables:
  - – recommend updates to associated policy, guidance, and standards documents
  - – develop VV&A XML schema and VV&A ontology for M&S
  - – produce DVDT

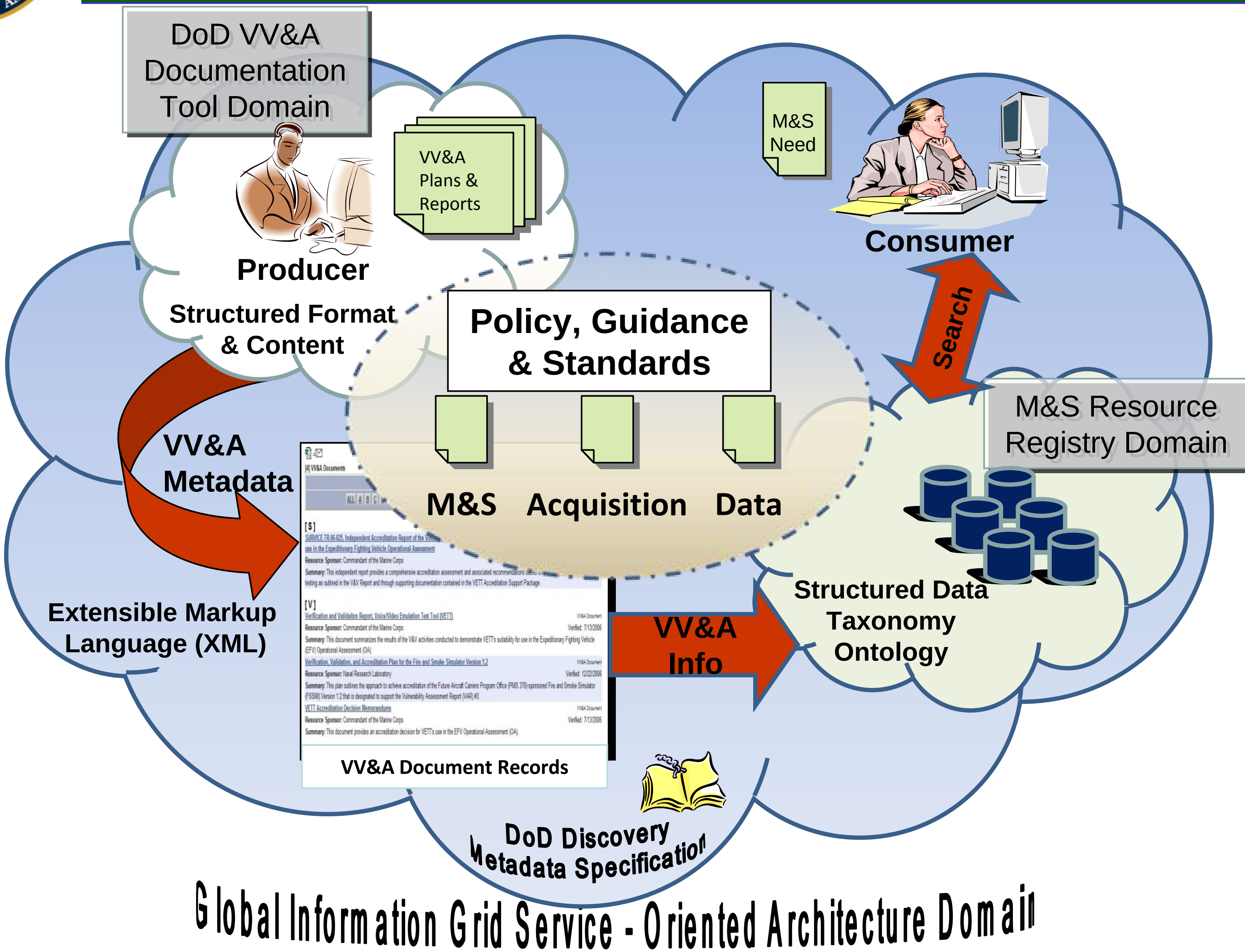
M&S Practices Gaps

- Address gaps documented in M&S SC Common and Cross-Cutting Business Plan
- **REUSE**
  - Potential users find it difficult to
    - locate, access, and assess M&S resources and to identify potential reuse candidates
    - clearly understand the capabilities of candidate model and simulation resources
    - assess the difference between the functionality of reuse candidates and the capabilities that are needed
- **VV&A**
  - There is no mature method for deriving VV&A costs
  - Standardized VV&A documentation templates are needed

Acquisition Objectives & Actions

- Address objectives and actions identified in the DoD Acquisition M&S Master Plan
- **OBJECTIVES**
  - Obj 2: Enhance the technical framework for M&S
  - Obj 4: Improve M&S use
- **ACTIONS**
  - Establish a standard template of key characteristics (metadata) to describe reusable M&S resources
  - Enhance the means (e.g., directory service, registries, bulletin boards) to discover the existence of reusable resources required for M&S and contact information
  - Require standardized documentation of VV&A DoD-wide

Concept of Operations



Policy, Guidance & Standards

Level 1

- M&S → DoDI 5000.59
- Acquisition → DoDI 5000.2
- Data → DoD Discovery Metadata Specification (DDMS)

Level 2

MIL-STD XXX002 → DoDI 5000.61 → DoD VV&A Recommended Practices Guide

Defense Acquisition Guidebook
- Sec 4.5.7 M&S

→ DAU Continuous Learning Modules
- CLE011 M&S in Sys Eng
- CLE 023 M&S for T&E

VV&A information is important not only for the decision at hand, but for future decisions to reuse M&S

Policy, Guidance & Standards

- Develop recommended changes to policy, guidance, and standards documents to advocate:
  - making the standardized templates a MIL-STD
  - using standardized templates for documenting VV&A
  - automating production of VV&A information
- Provide recommendations to Acquisition M&S Working Group
- Deliver recommendations to Acquisition member of M&S Steering Committee (M&S SC):
  - formally request changes to related policy, guidance, and standards documents through Communities

Policy, Guidance & Standards Recommendations

M&S Steering Committee

AMSWG & M&S IPT

DoD M&S Project

Project Management Team

Formulate

M&S
VV&A forums

Acquisition
Acquisition M&S Working Group

Data
DoD Metadata Working Group

Coordinate

DoD Communities

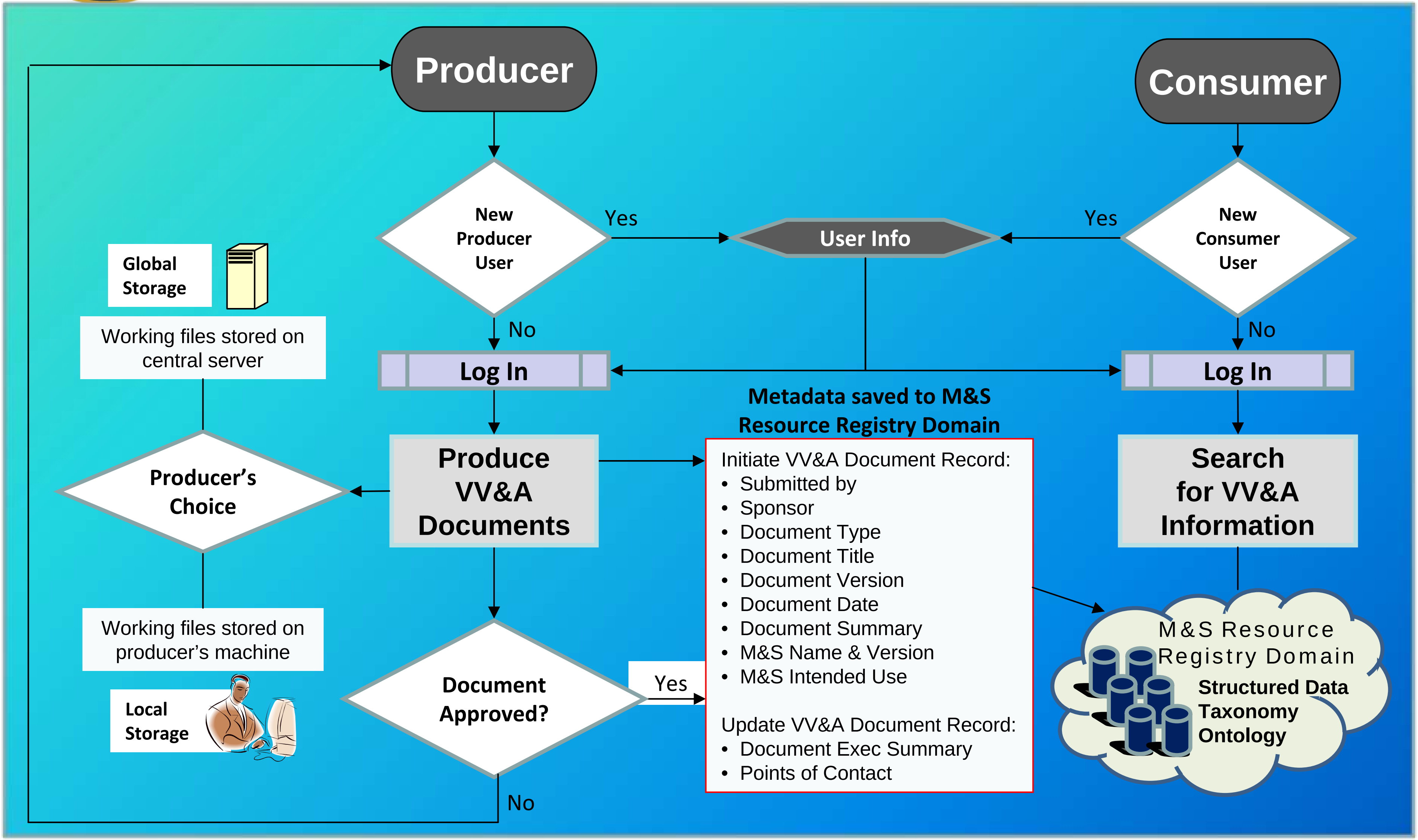
Advocate

M&S
USD(AT&L)

Acquisition
USD(AT&L)

Data
DASD (IM&T) Deputy CIO

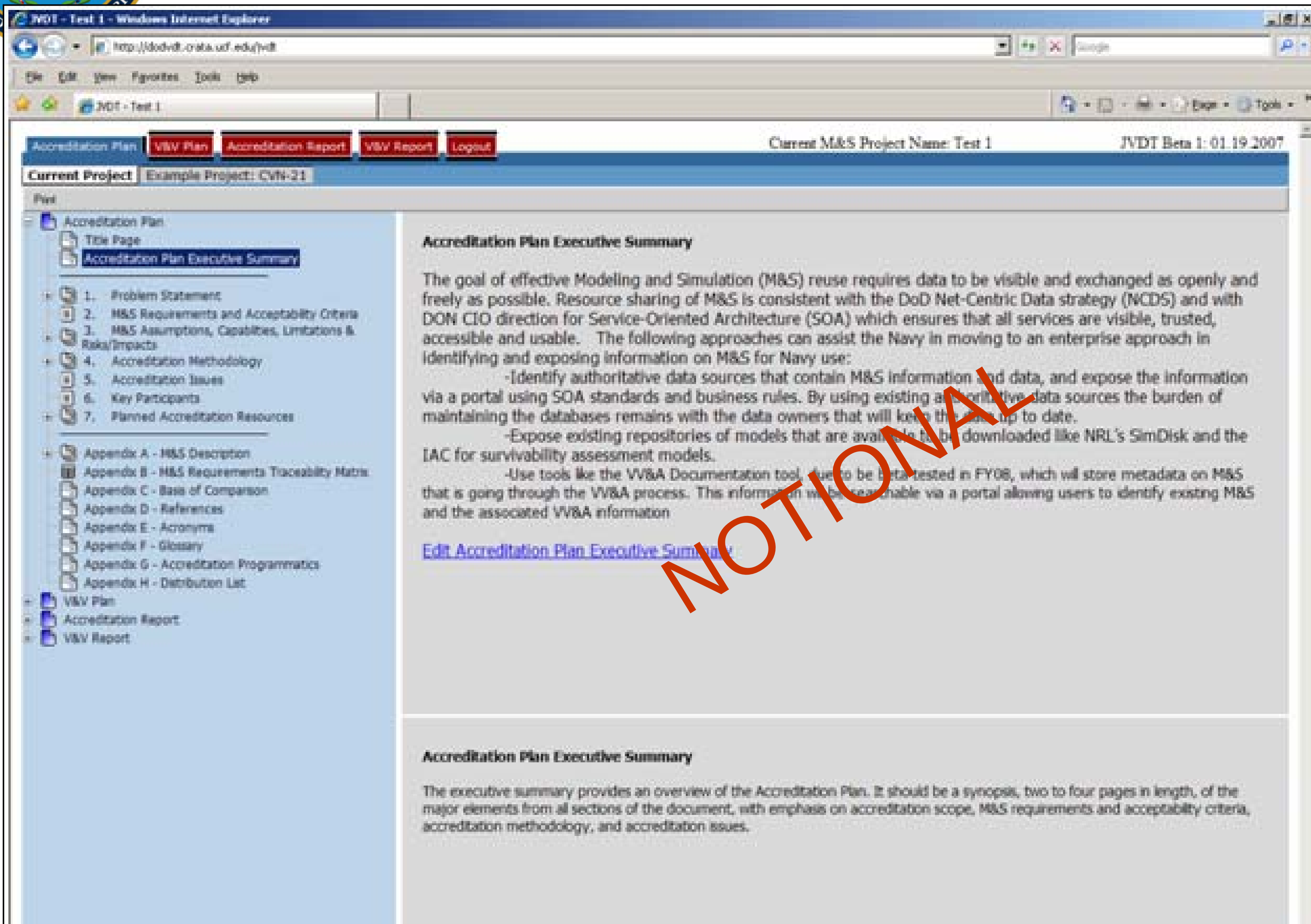
Producer / Consumer View



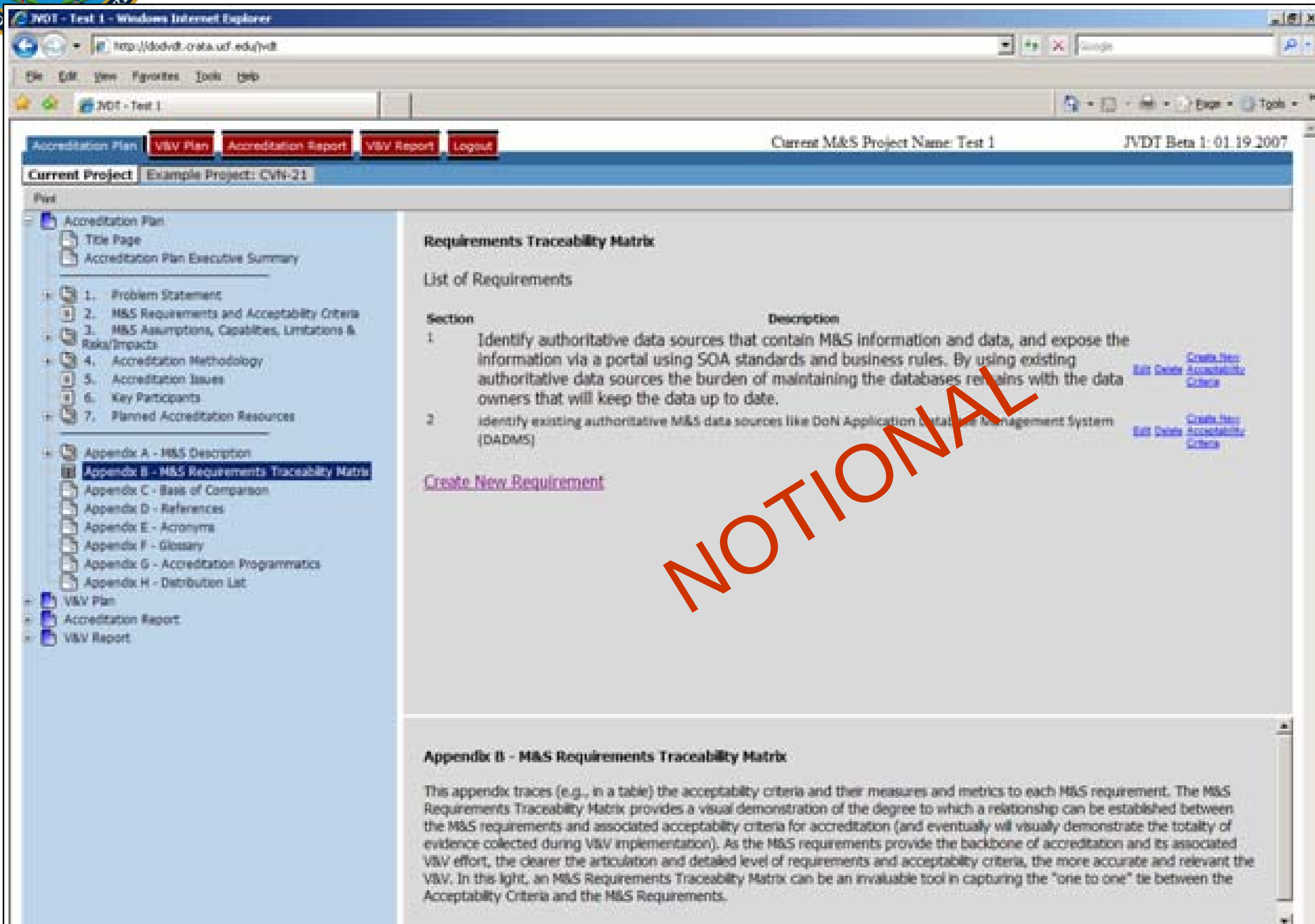
DoD VV&A Documentation Tool (DVDT)

- Technology development effort to automate standard DoD VV&A templates
- Benefits to automation
  - expedites VV&A documentation production process
  - ensures standardization of content and format across DoD
  - ensures compliance with policy and guidance
  - guides Producer through the VV&A processes
  - enables content consistency and completeness across all Communities
  - facilitates and contributes to M&S reuse
  - provides quality and complete VV&A information to stakeholders faced with making decisions on the application of M&S results
  - provide standardized methods to communicate VV&A information at appropriate levels of detail
  - ensures appropriate/useful metadata is extracted and posted

DVDT (1)


JVDT - Test 1 - Windows Internet Explorer
http://dodvdt.crata.ucf.edu/jvdt
File Edit View Favorites Tools Help
JVDT - Test 1
Accreditation Plan
V&V Plan
Accreditation Report
V&V Report
Logout
Current M&S Project Name: Test 1
JVDT Beta 1: 01.19.2007
Current Project
Example Project: CVN-21
Accreditation Plan
Title Page
Accreditation Plan Executive Summary
1. Problem Statement
2. M&S Requirements and Acceptability Criteria
3. M&S Assumptions, Capabilities, Limitations & Risks/Impacts
4. Accreditation Methodology
5. Accreditation Issues
6. Key Participants
7. Planned Accreditation Resources
Appendix A - M&S Description
Appendix B - M&S Requirements Traceability Matrix
Appendix C - Basis of Comparison
Appendix D - References
Appendix E - Acronyms
Appendix F - Glossary
Appendix G - Accreditation Programmatics
Appendix H - Distribution List
V&V Plan
Accreditation Report
V&V Report
Accreditation Plan Executive Summary
The goal of effective Modeling and Simulation (M&S) reuse requires data to be visible and exchanged as openly and freely as possible. Resource sharing of M&S is consistent with the DoD Net-Centric Data strategy (NCDS) and with DON CIO direction for Service-Oriented Architecture (SOA) which ensures that all services are visible, trusted, accessible and usable. The following approaches can assist the Navy in moving to an enterprise approach in identifying and exposing information on M&S for Navy use:
-Identify authoritative data sources that contain M&S information and data, and expose the information via a portal using SOA standards and business rules. By using existing authoritative data sources the burden of maintaining the databases remains with the data owners that will keep the data up to date.
-Expose existing repositories of models that are available to be downloaded like NRL's SimDisk and the IAC for survivability assessment models.
-Use tools like the VV&A Documentation tool, due to be beta tested in FY08, which will store metadata on M&S that is going through the VV&A process. This information will be searchable via a portal allowing users to identify existing M&S and the associated VV&A information
Edit Accreditation Plan Executive Summary
NOTIONAL
Accreditation Plan Executive Summary
The executive summary provides an overview of the Accreditation Plan. It should be a synopsis, two to four pages in length, of the major elements from all sections of the document, with emphasis on accreditation scope, M&S requirements and acceptability criteria, accreditation methodology, and accreditation issues.

DVDT (2)


JVDT - Test 1 - Windows Internet Explorer
http://dodvdt.crata.ucf.edu/jvdt
File Edit View Favorites Tools Help
JVDT - Test 1
Accreditation Plan
V&V Plan
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Current M&S Project Name: Test 1
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Accreditation Plan Executive Summary
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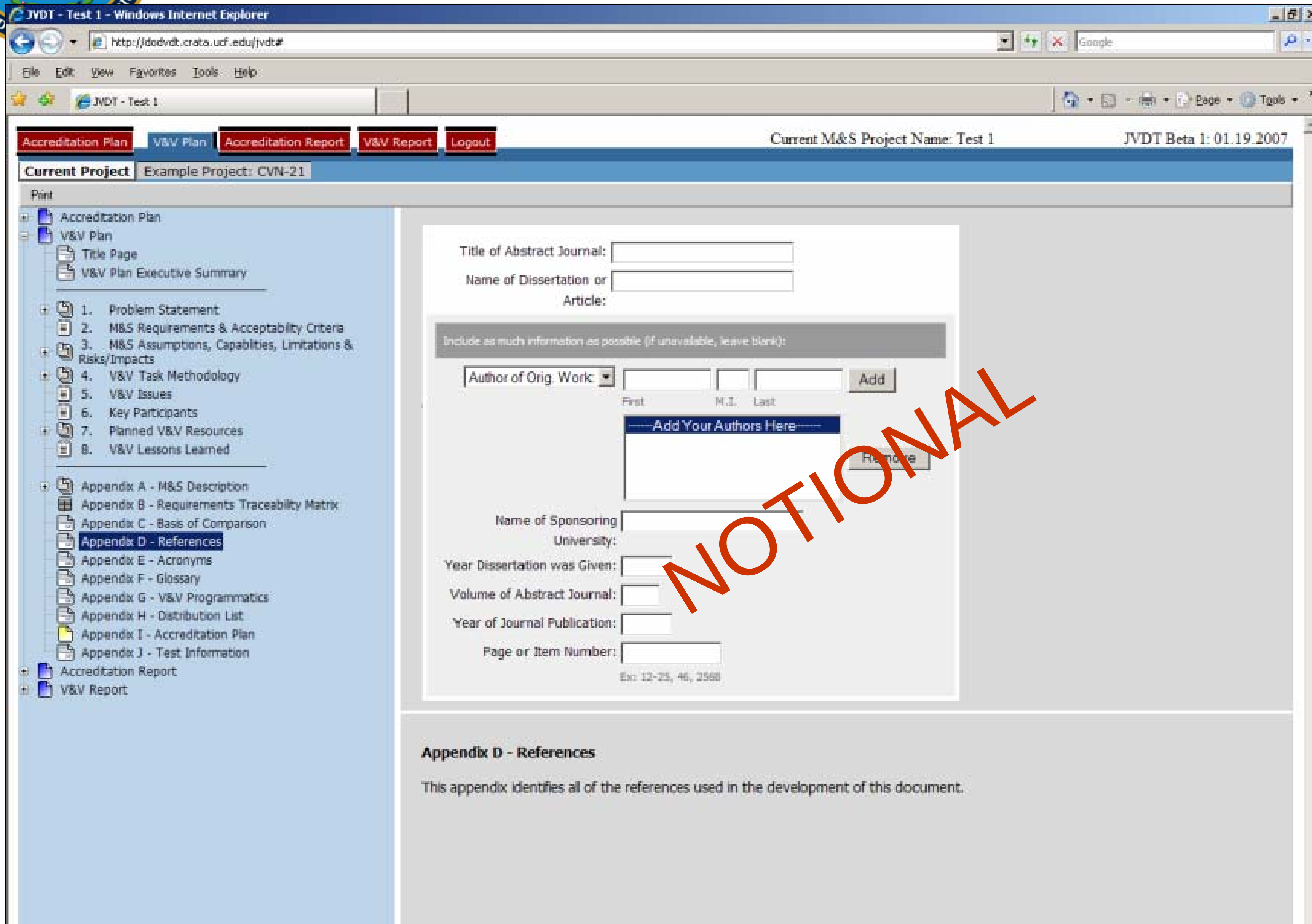
4. Accreditation Methodology
5. Accreditation Issues
6. Key Participants
7. Planned Accreditation Resources
Appendix A - M&S Description
Appendix B - M&S Requirements Traceability Matrix
Appendix C - Basis of Comparison
Appendix D - References
Appendix E - Acronyms
Appendix F - Glossary
Appendix G - Accreditation Programmatics
Appendix H - Distribution List
V&V Plan
Accreditation Report
V&V Report
Requirements Traceability Matrix
List of Requirements
Section
Description
1
Identify authoritative data sources that contain M&S information and data, and expose the information via a portal using SOA standards and business rules. By using existing authoritative data sources the burden of maintaining the databases remains with the data owners that will keep the data up to date.
Edit Delete Create New Acceptability Criteria
2
identify existing authoritative M&S data sources like DoN Application Database Management System (DADMS)
Edit Delete Create New Acceptability Criteria
Create New Requirement
NOTIONAL
Appendix B - M&S Requirements Traceability Matrix
This appendix traces (e.g., in a table) the acceptability criteria and their measures and metrics to each M&S requirement. The M&S Requirements Traceability Matrix provides a visual demonstration of the degree to which a relationship can be established between the M&S requirements and associated acceptability criteria for accreditation (and eventually will visually demonstrate the totality of evidence collected during V&V implementation). As the M&S requirements provide the backbone of accreditation and its associated V&V effort, the clearer the articulation and detailed level of requirements and acceptability criteria, the more accurate and relevant the V&V. In this light, an M&S Requirements Traceability Matrix can be an invaluable tool in capturing the "one to one" tie between the Acceptability Criteria and the M&S Requirements.

DVDT (3)


JVDT - Test 1 - Windows Internet Explorer
http://dodvdt.crata.ucf.edu/jvdt#
File Edit View Favorites Tools Help
JVDT - Test 1
Page Tools
Accreditation Plan
V&V Plan
Accreditation Report
V&V Report
Logout
Current M&S Project Name: Test 1
JVDT Beta 1: 01.19.2007
Current Project
Example Project: CVN-21
Print
Accreditation Plan
V&V Plan
Title Page
V&V Plan Executive Summary
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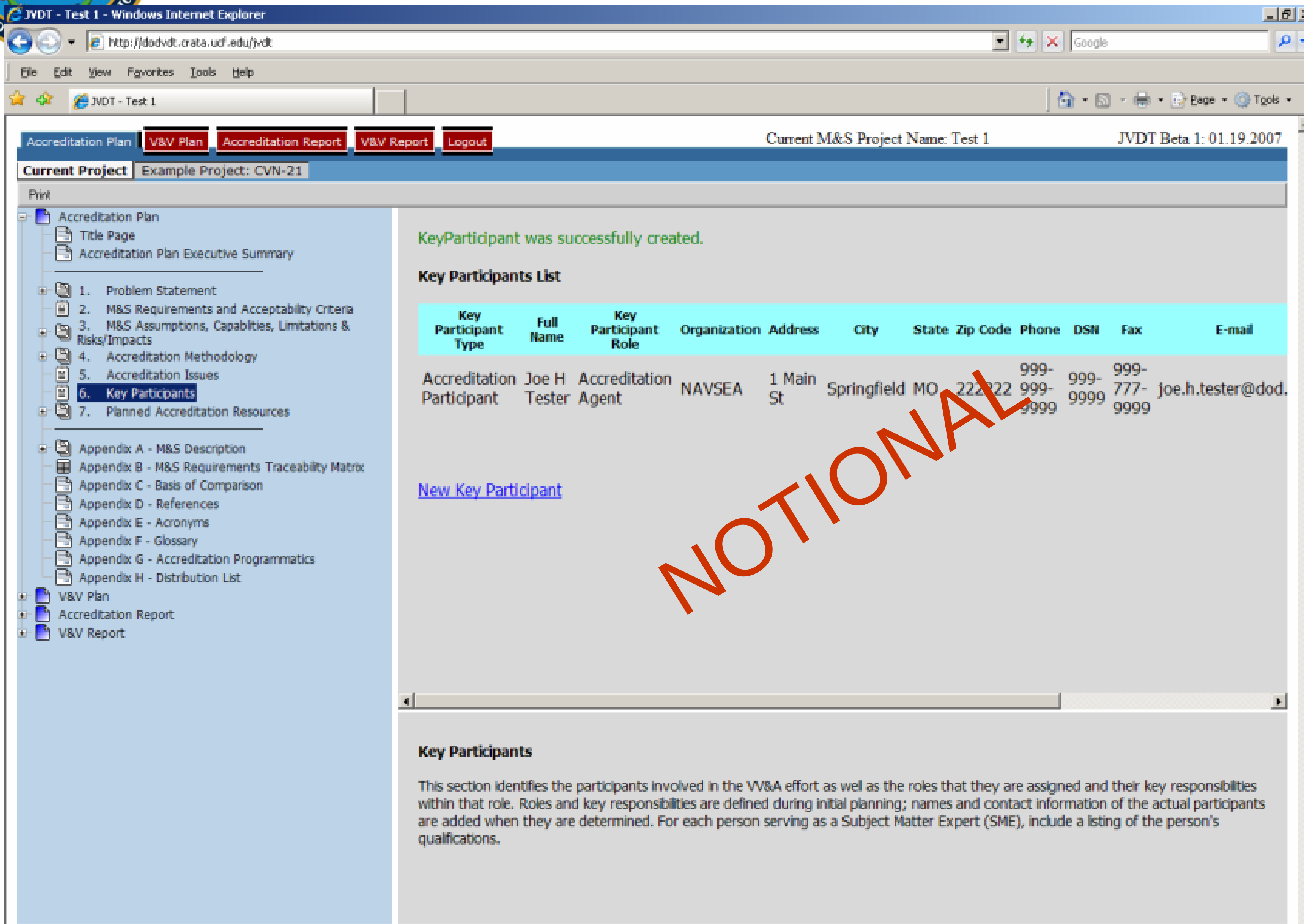
2. M&S Requirements & Acceptabilty Criteria
3. M&S Assumptions, Capablities, Limitations & Risks/Impacts
4. V&V Task Methodology
5. V&V Issues
6. Key Participants
7. Planned V&V Resources
8. V&V Lessons Learned
Appendix A - M&S Description
Appendix B - Requirements Traceabilty Matrix
Appendix C - Basis of Comparison
Appendix D - References
Appendix E - Acronyms
Appendix F - Glossary
Appendix G - V&V Programmatics
Appendix H - Distribution List
Appendix I - Accreditation Plan
Appendix J - Test Information
Accreditation Report
V&V Report
Title of Abstract Journal:
Name of Dissertation or Article:
Include as much information as possible (if unavailable, leave blank):
Author of Orig. Work
Add
First
M.I.
Last
-----Add Your Authors Here-----
Remove
Name of Sponsoring University:
Year Dissertation was Given:
Volume of Abstract Journal:
Year of Journal Publication:
Page or Item Number:
Ex: 12-25, 46, 2568
NOTIONAL
Appendix D - References
This appendix identifies all of the references used in the development of this document.

DVDT (4)



JVDT - Test 1 - Windows Internet Explorer
http://dodvdt.crata.ucf.edu/jvdt
File Edit View Favorites Tools Help
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V&V Report
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Current M&S Project Name: Test 1
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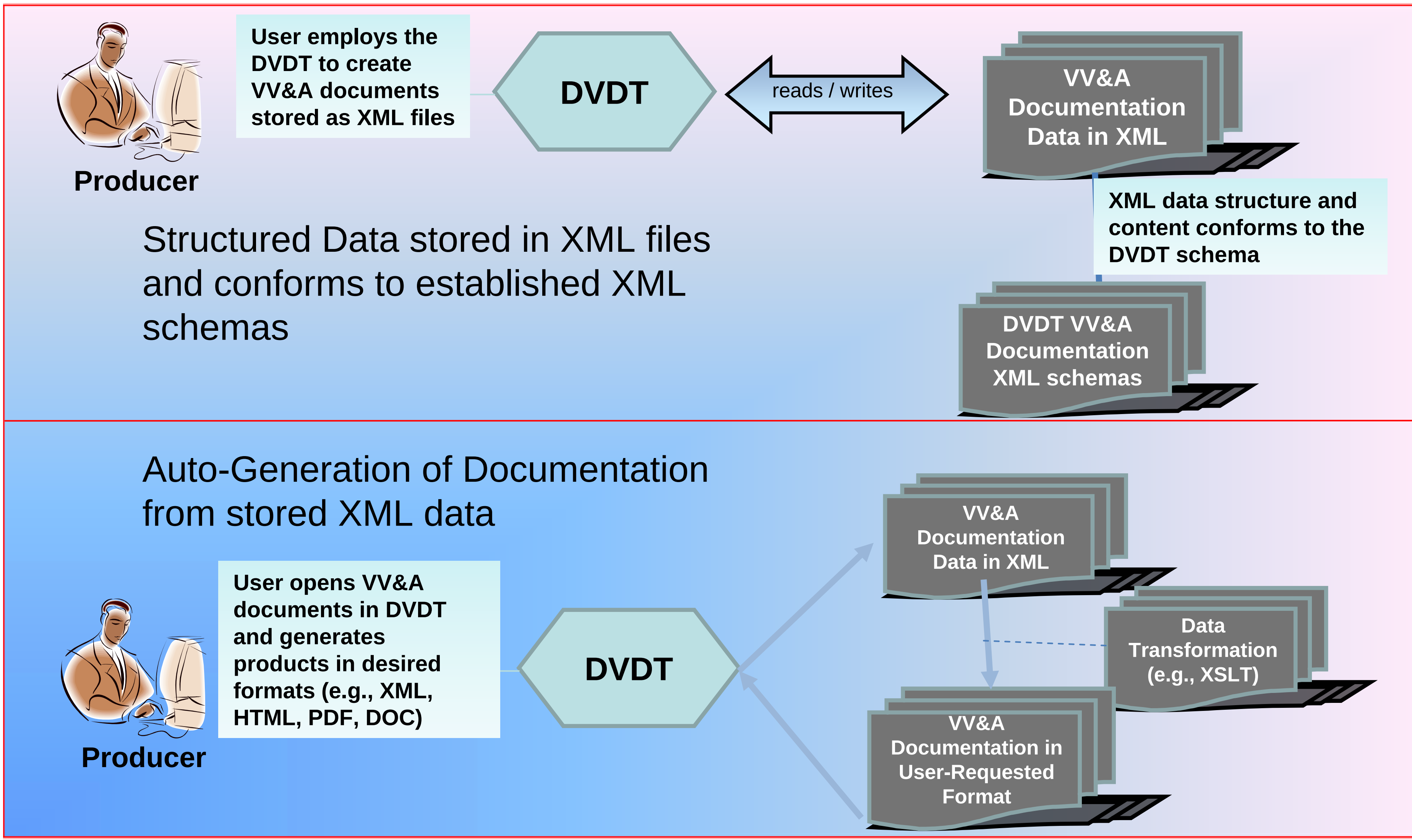
Appendix F - Glossary
Appendix G - Accreditation Programmatics
Appendix H - Distribution List
V&V Plan
Accreditation Report
V&V Report
KeyParticipant was successfully created.
Key Participants List
Key Participant Type | Full Name | Key Participant Role | Organization | Address | City | State | Zip Code | Phone | DSN | Fax | E-mail
Accreditation Participant | Joe H Tester | Accreditation Agent | NAVSEA | 1 Main St | Springfield | MO | 222222 | 999-999-9999 | 999-9999 | 999-777-9999 | joe.h.tester@dod.
NOTIONAL
New Key Participant
Key Participants
This section identifies the participants involved in the VV&A effort as well as the roles that they are assigned and their key responsibilities within that role. Roles and key responsibilities are defined during initial planning; names and contact information of the actual participants are added when they are determined. For each person serving as a Subject Matter Expert (SME), include a listing of the person's qualifications.

Structured VV&A Documents

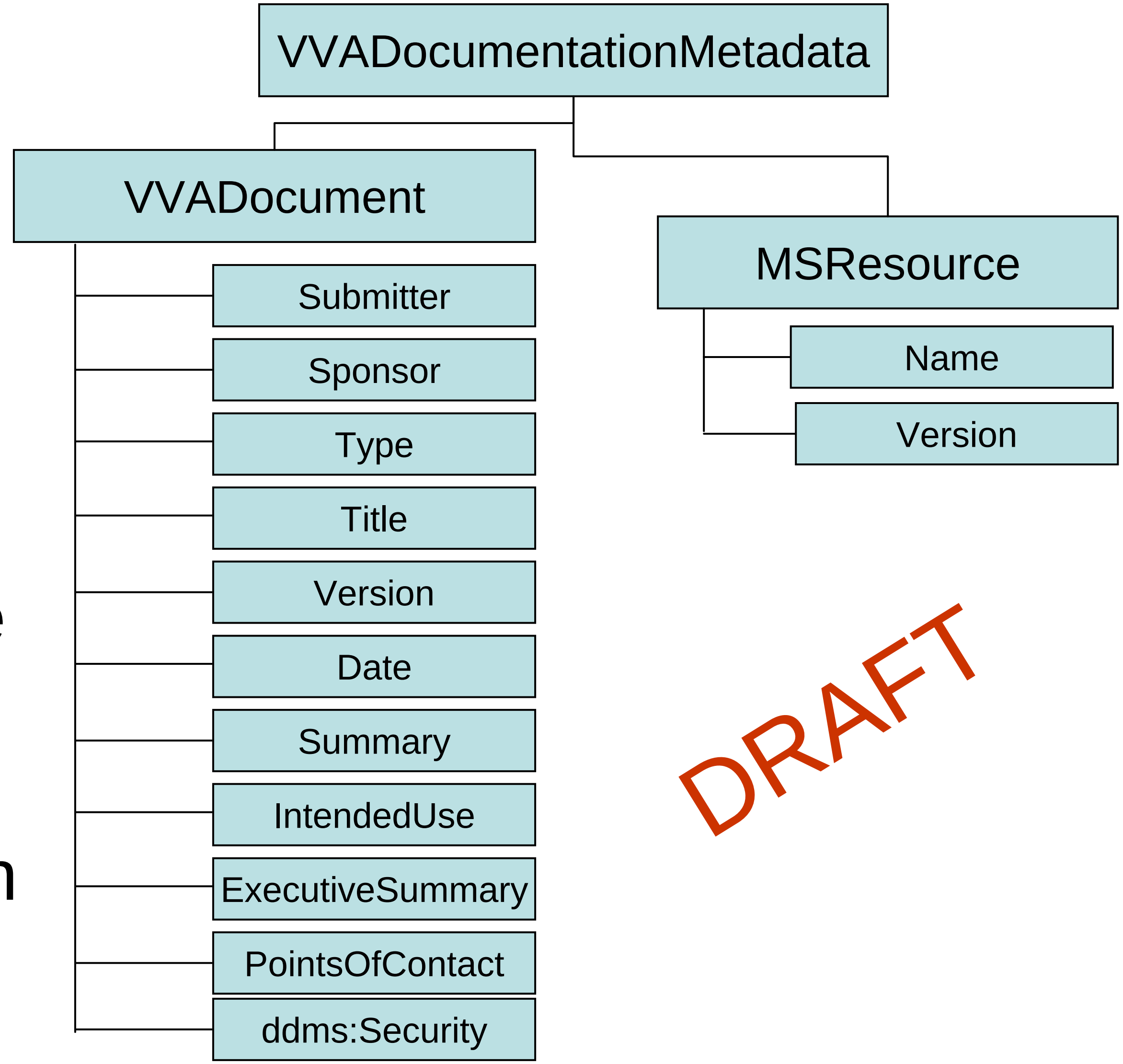
- Effective data sharing requires the commonly understood representation of the data
- Defined and published data structures facilitate information exchange and application development

VV&A Documents (Structured Data and Semantics)



VV&A Metadata XML Schema (Draft)

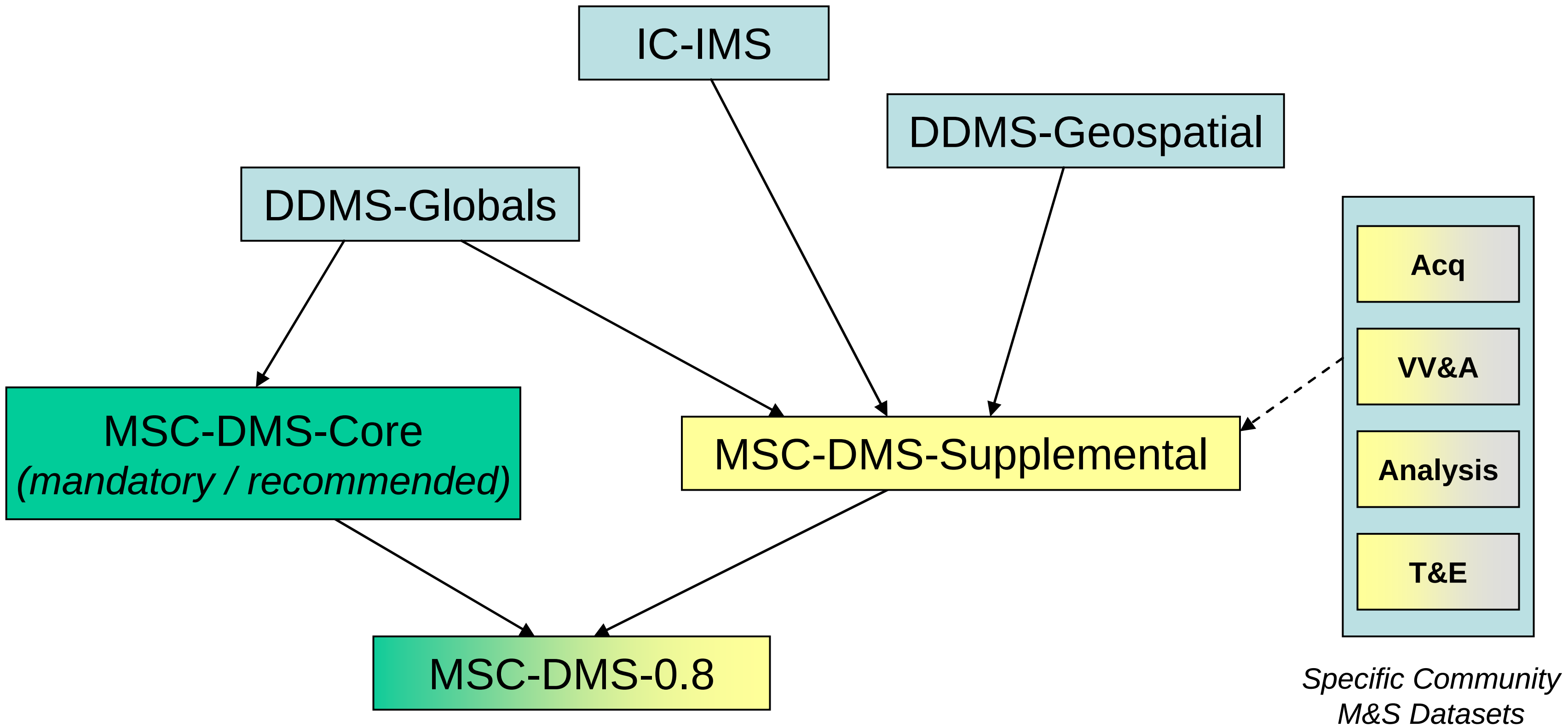
- Describes data types and constraints compliant with XML Schema definitions
- Metadata will be published to the M&S Resource Registry Domain



Metadata Design Considerations

- Formalize structure and content of standard VV&A document templates into XML schemas
- Capture key elements from the standard VV&A document templates for posting to the M&S resource registry
- Include mandatory DoD Discovery Metadata Specification (DDMS) elements sufficient to construct valid DDMS Resource metadata document
- Include mandatory DoD M&S Community of Interest Discovery Metadata Specification elements
- Reuse existing XML namespaces directly or through transformations (mappings)
- Comply with best practice as described in XML Naming and Design Rules (e.g., DoN, UN/CEFACT)

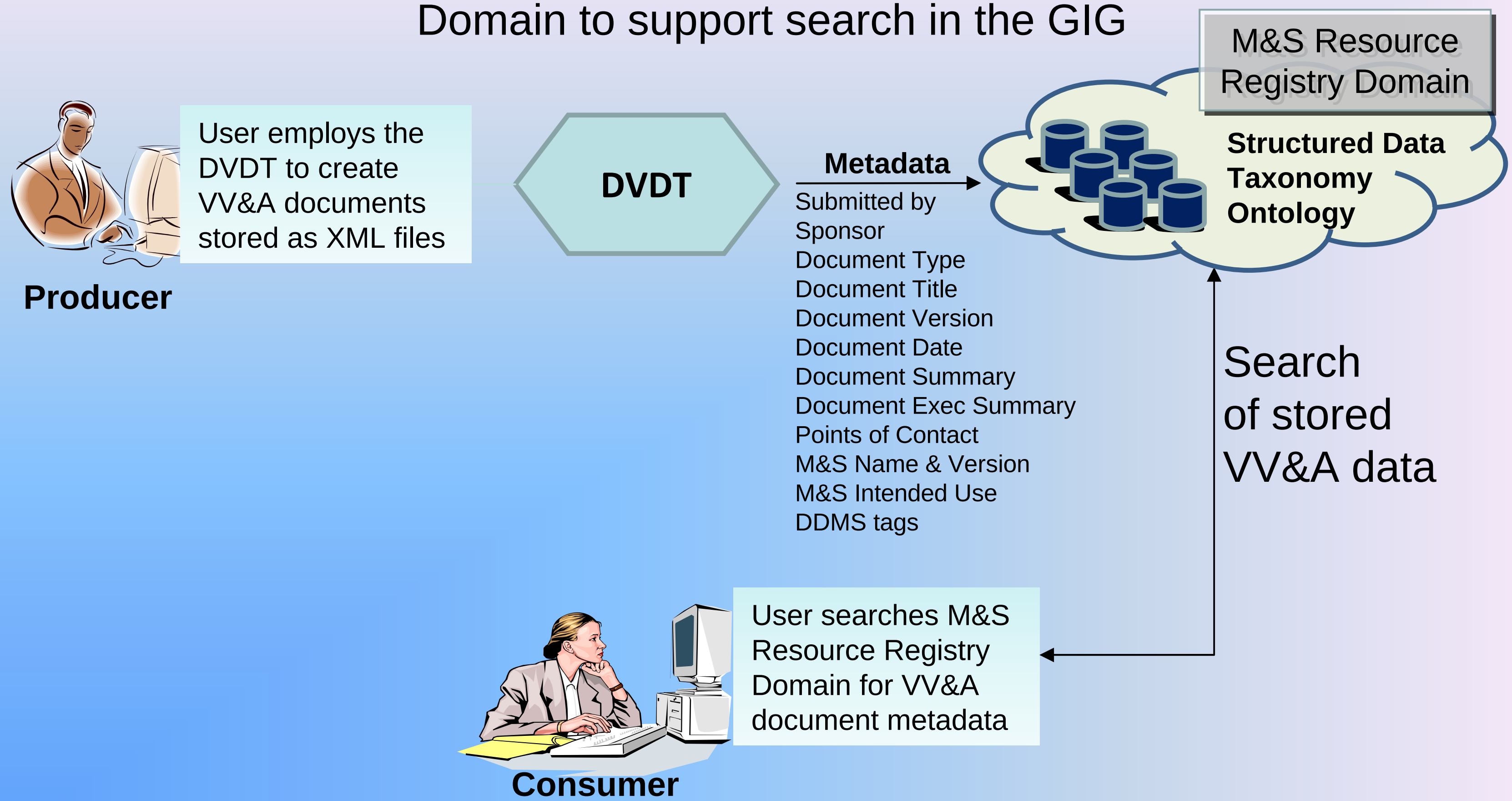
M&S COI Discovery Metadata Specification: Organization Structure



Specification work occurring in parallel with DVDT schema development offering opportunity to maximize compatibility and mutual benefit.

VV&A Metadata (Structured Data and Semantics)

DVDT generates VV&A metadata for posting to M&S Resource Registry Domain to support search in the GIG



Structured VV&A Metadata

- Consistent use of the DVDT across the DoD and Military Departments, will
  - enable publishing of VV&A metadata
  - facilitate discovery and sharing of VV&A information over the Global Information Grid (GIG)
- Align metadata design with DoD Discovery Metadata Specification (DDMS) and M&S Community of Interest Discovery Metadata Specification

VV&A Ontology for M&S

- Establishes technical case for application of formalized semantics relating to VV&A processes and records
- Employed by software and humans to discover M&S resources and to assess suitability for the intended use
- Will use Web Ontology Language (OWL) and other Semantic Web standards

Plan of Action and Milestones

Points of Contact

For more information,
to become a DVDT beta tester, or
to use the DVDT to support a VV&A project,
contact any one of the authors below.

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Curtis Blais
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Monterey, CA 93943-5001
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clblais@nps.edu

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301-317-9698
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Acronyms

DMSP	DoD M&S Project
DoD	Department of Defense
DT&E	Developmental Test and Evaluation
DVDT	DoD VV&A Documentation Tool
GIG	Global Information Grid
IPT	Integrated Product Team
M&S	Modeling and Simulation, model(s) and simulation(s)
M&S CO	M&S Coordination Office
M&S SC	M&S Steering Committee
PMT	Project Management Team
ODUSD(A&T)	Office of the Deputy Under Secretary of Defense (Acquisition & Technology)
POA&M	Plan of Action and Milestones
SSE	Systems & Software Engineering
VV&A	Verification, Validation, and Accreditation
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language for Transformations

Acquisition M&S Community Sponsored M&S Project: Standardized Documentation for Verification, Validation, and Accreditation - A Status Report to the Systems Engineering Community

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ABSTRACT: *Using models and simulations that provide credible results in the systems engineering process is crucial to fielding defense weapon systems more effectively to the warfighter. Employing distributed, live-virtual-constructive synthetic environments that produce results that can be used with confidence is essential to support development and testing of interoperable systems for joint capabilities. Credibility and confidence in the use of modeling and simulation (M&S) results can be achieved only through the implementation of standard Verification, Validation, and Accreditation (VV&A) processes. M&S is a key enabler for systems engineers throughout the acquisition process. VV&A is critical for ensuring an M&S is correct, is used correctly, and can produce results a systems engineer can trust.*

The Department of Defense (DoD) Modeling and Simulation Steering Committee (M&S SC) Acquisition M&S Community Lead, Mr. Chris DiPetto, Deputy Director for Developmental Test and Evaluation, is sponsoring several Acquisition M&S Projects. One of those projects is titled, "Standardized Documentation for Verification, Validation, and Accreditation." This paper will update the Systems Engineering Community on what the project is about and progress that has been made. It will provide information on the development of standardized content and format requirements for four core VV&A documents, the technology development efforts to automate those templates to ensure standardization across the DoD and Military Departments, and the work underway to identify VV&A metadata that will enable the sharing of information across all M&S Communities via the Global Information Grid anywhere in the world and at anytime. Additionally, the paper will identify gaps from the M&S SC Common and Cross-Cutting Business Plan and objectives from the DoD Acquisition M&S Master Plan that are being addressed by this project. Finally, the paper will provide an overview of the project including scope, schedule, and deliverables.

1. Introduction

The Department of Defense (DoD) Modeling and Simulation Steering Committee (M&S SC) Acquisition M&S Community Lead, Mr. Chris DiPetto, Deputy Director for Developmental Test and Evaluation, is sponsoring several Acquisition Modeling and Simulation (M&S) Projects. One of those projects is titled, "Standardized Documentation for Verification, Validation, and Accreditation (VV&A)." This paper updates the Systems Engineering Community on what the project is about and progress that has been made. It provides information on the development of standardized content and format requirements (i.e., templates) for four core VV&A documents, the technology development efforts to automate those templates to ensure standardization across the DoD and Military Departments, and the work underway to identify VV&A metadata that will enable the sharing of information across all Communities enabled by M&S via the Global Information Grid (GIG) anywhere in the world and at anytime. Additionally, the paper identifies gaps from the M&S SC Common and Cross-Cutting Business Plan and objectives from the DoD Acquisition M&S Master Plan that are being addressed by this project. Finally, it provides an overview of the project including scope, schedule, and deliverables.

Using models and simulations that provide credible results in the systems engineering process is crucial to fielding defense weapon systems more effectively to the warfighter. Employing distributed, live-virtual-constructive synthetic environments that produce results that can be used with confidence is essential to support development and testing of interoperable systems for joint capabilities. Confidence in the use of M&S results can be achieved only through the implementation of standard VV&A processes that are understood and employed by the M&S communities. M&S is a key enabler for systems engineers throughout the acquisition process. VV&A is critical for ensuring an M&S is correct, is used correctly, and can produce results a systems engineer can trust.

2. Background

DoD Instruction (DoDI) 5000.61 [1] sets policy requiring accreditation of all models and simulations "used to support major DoD decision-making organizations and processes" and all models and simulations "used to support joint training and joint exercises." The Instruction requires DoD components to "establish VV&A policies and procedures for models and simulations they develop, use, or manage." Moreover, the Instruction requires Principal Staff Assistants and heads of the DoD Components to hold M&S proponents accountable and responsible for "verification and validation of their assigned M&S, as well as the documentation of those activities," and to hold individual data producers accountable and responsible for "the quality of their data or data products provided for M&S use."

Since 1996 when DoDI 5000.61 [1] was first promulgated, organizations DoD-wide have been attempting to implement VV&A processes and capture VV&A information. Over the years, guidance for implementing VV&A was provided in the form of Service- and organizational-level instructions, recommended practices, guidebooks, handbooks, and standards. The requirements for documenting VV&A information varied from Service-to-Service, organization-to-organization, and community-to-community, but generally all required the same types of information needed to gain confidence in the application of M&S results for an intended use. Because there were common general requirements, the Service VV&A representatives came together in 2005 as part of a DoD-sponsored VV&A Templates Tiger Team to begin work on developing one set of templates for four core VV&A documents: the Accreditation Plan, V&V Plan, V&V Report, and the Accreditation Report. The purpose was to enable expanded M&S reuse by building the foundation for consistent V&V information to support accreditation decisions. The result of that effort will be a DoD Standard Practice (draft MIL-STD-XXX002) [2] that provides a common framework for the sharing of information throughout the VV&A process. The templates captured in the standard practice will be automated by the DoD VV&A Documentation Tool (DVDT). Using templates with standard format and content requirements to document VV&A information across DoD will help users better understand if an M&S can meet their needs because they will know what kind of information is available and where to look in the document for that information.

The DVDT is the latest tool to address the need to capture VV&A information in a consistent format with consistent content. Prior prototype versions used by various organizations across DoD, preceded the DVDT and provided the baseline for functional requirements [3]. The DVDT will be discussed more in Section 4.

2.1 Sharing VV&A Information

> *The primary product of the VV&A processes is information.* [4]

Documenting VV&A information consistently across DoD will yield many returns, one of which is the capability to share that information with future users of M&S. VV&A information can tell a potential user about the M&S assumptions, capabilities, and limitations. It

provides a description of what the M&S can be used to do (capabilities) and also what it should not be used to do (limitations). This information can save time and money for potential users if they can find a match that satisfies or partially satisfies their needs to use M&S.

> *Using standardized terminology will make VV&A information easier to discover and share over the GIG.* [5]

An ontology defines a common vocabulary and a shared understanding that enables reuse of knowledge. A common VV&A vocabulary will enable the development of a standard XML schema that will facilitate the sharing of VV&A information in GIG service-oriented and net-centric architectures.

Warfighters around the world depend on M&S and need ready access to VV&A information that can provide them the basis for using M&S results to inform decisions. It is Joint Staff policy to assure that all information technology (e.g., M&S) that is used to support operations meet interoperability requirements and are supportable over the GIG [6]. Section 5 will discuss these efforts in more detail.

2.2 Gaps, Objectives, and Actions

This DoD M&S Project (discussed more in Section 3) addresses gaps affecting the effective use of M&S throughout DoD identified in the M&S SC Common and Cross-Cutting Business Plan [7]. That business plan captures in one place corporate level M&S requirements and needed capabilities. The gaps are segregated into one of three sections — Technology, M&S Practices, and Representations.

The M&S Practices area addresses the guidance, business rules, and information exchange mechanisms that support planning, development, and use of M&S. Reuse and VV&A are identified as M&S Practices gap areas:

REUSE
Potential users find it difficult to:
- locate, access, and assess M&S resources and to identify potential reuse candidates,
- clearly understand the capabilities of candidate model and simulation resources, and
- to assess the difference between the functionality of reuse candidates and the capabilities that are needed.

VV&A
- There is no mature method for deriving VV&A costs.
- Standardized VV&A documentation templates are needed

The DoD M&S Project addresses these gaps. In addition, because the DoD M&S Project is sponsored by the Acquisition Community Lead, it also addresses the following objectives and actions identified within the DoD Acquisition M&S Master Plan [8].

OBJECTIVES
- Enhance the technical framework for M&S.
- Improve M&S use.

ACTIONS
- Establish a standard template of key characteristics (metadata) to describe reusable M&S resources.
- Enhance the means (e.g., directory service, registries, bulletin boards) to discover the existence of reusable resources required for M&S and contact information.
- Require standardized documentation of VV&A DoD-wide.

The Master Plan documents the actions needed to improve M&S support to the DoD acquisition process. The specific actions defined within the plan will foster better tools and processes to support systems engineering, acquisition decision making, development of joint capabilities, and realization of cost efficiencies [8].

3. DoD M&S Project

The M&S SC established several DoD M&S Projects in FY07 through the proposal process depicted in Figure 1 and described below.

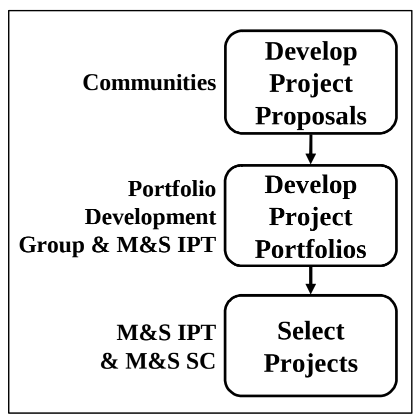

Figure 1. M&S SC Proposal Process

Develop Project Proposals — Communities led the development of and submittal of proposals for projects addressing gaps in the M&S SC Common and Cross-Cutting Business Plan [7].

Develop Project Portfolios — The M&S Integrated Product Team (IPT) and the Portfolio Development Group assessed the project proposals and identified promising proposals that addressed the gaps. These two

groups then worked with the proposal submitters to improve the proposal's ability to address gaps.

Select Projects — The M&S IPT evaluated the proposals and made selection recommendations to the M&S SC. The M&S SC decided which proposals to fund.

This project was vetted successfully through that process, found to address several gaps and acquisition objectives, and selected for funding in FY07 with a period of performance through September 2008.

3.1 Acquisition Governance

The Acquisition Community M&S SC member provides oversight of the project through the Acquisition member of the M&S IPT. Figure 2 depicts the DoD acquisition governance structure [9].

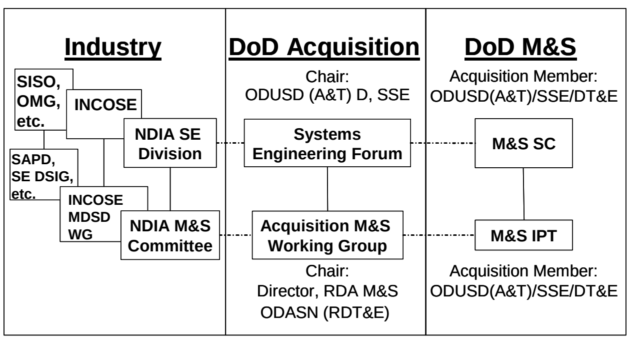

Figure 2. DoD Acquisition Governance Structure

The Acquisition M&S Working Group (AMSWG) is chartered by the DoD Systems Engineering Forum to assist program managers and acquisition professionals by improving the utility of M&S in the acquisition of defense capabilities. In this capacity, the AMSWG addresses common concerns, aligns technical initiatives, and pursues cross-cutting issue resolution [10]. Representing the interests of the acquisition M&S community, the AMSWG also acts as the sounding board for this project by providing guidance and direction with respect to requirements for the various tasks and deliverables.

3.2 Project Management

The team is led by the Space and Naval Warfare Systems Center (SPAWARSYSCEN) in Charleston, South Carolina, and its structure is depicted below in Figure 3.

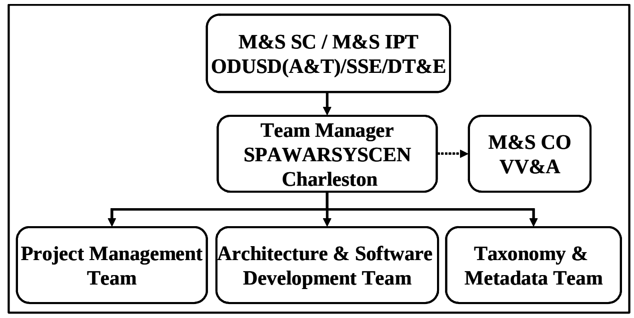

Figure 3. Project Management Structure

The Project Management Team and Architecture & Software Development Team both are led by SPAWARSYSCEN Charleston. The Taxonomy & Metadata Team is led by the Naval Postgraduate School.

3.3 Scope

The project has three major tasks and associated deliverables:

- Produce the DVDT
- Develop a VV&A XML schema and VV&A ontology for M&S
- Recommend updates to associated policy, guidance, and standards documents

The purpose of the project is to support the various DoD- and Service-level communities by delivering a tool that produces standardized VV&A documentation and a VV&A XML schema that meets net-centric architecture requirements for sharing, discovering, and retrieving VV&A information within the GIG enterprise. The project is also working towards incorporating references to the standard practice, DVDT, and VV&A metadata into the appropriate M&S, data, and acquisition policy and guidance documents.

The beta versions of the DVDT and supporting XML schema are expected in the first quarter of FY08. The final versions of the tool, XML schema, and VV&A ontology are scheduled for fourth quarter of FY08.

3.4 Concept of Operations

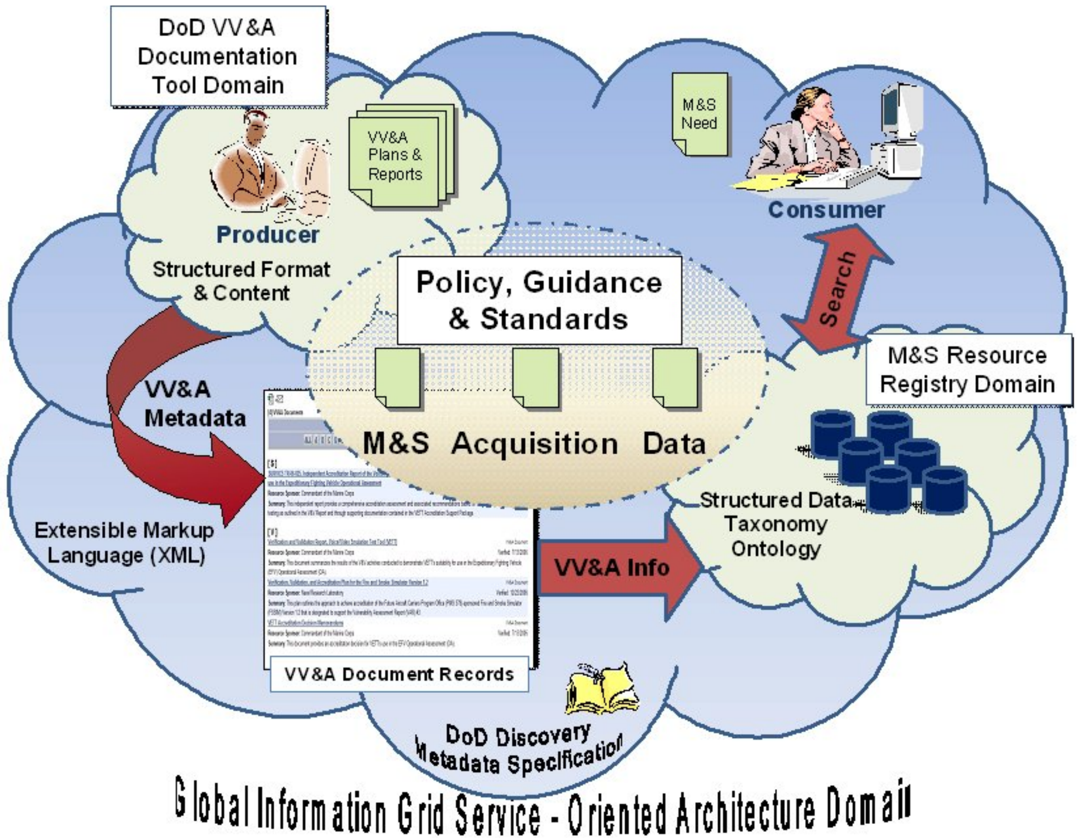

Figure 4. High Level Concept of Operations

Figure 4 presents the high-level concept of operations for how the three major deliverables support the M&S communities.

Policy, guidance, and standards in the areas of M&S, acquisition, and data (depicted in Figure 5) form the foundation for everything to work together.

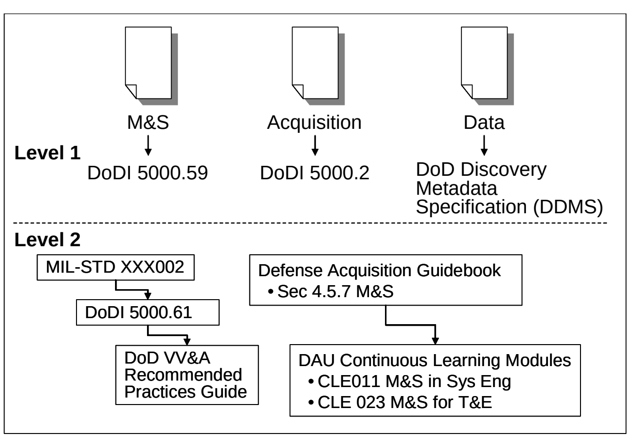

Figure 5. Policy, Guidance & Standards

Ensuring consistent use of the DVDT across the DoD and Military Departments, will enable publishing of VV&A metadata, which, in turn, will facilitate the discovery and sharing of VV&A information over the GIG. The new DoDD 5000.59 [11] was signed in August 2007 and states that "M&S management shall … pursue common and cross-cutting M&S tools, data, and services." Additionally, it provides direction to the M&S SC to "oversee … the implementation of best practices of how models and simulations are effectively acquired, developed, managed, and used by DoD Components (e.g., verification, validation, and accreditation; standards, and protocols)." Based upon the specificity of the published directive, a new instruction (DoDI 5000.59) may well be needed to implement the provisions in the directive. Along with DoDD 5000.59 [11], the new instruction will be important for all matters related to M&S across DoD. DoDI 5000.2 [12] is key to acquisition procedures for using M&S. Affecting change to these two important level-1 documents will be worked through the appropriate channels.

Another important aspect of this task is to affect changes in level-2 policy, guidance, and standards documents. The level-2 M&S documents include, the draft DoD Standard Practice (MIL-STD-XXX002) [2], DoD 5000.61 [1], and the online VV&A Recommended Practices Guide [13]. The level-2 acquisition documents include the Defense Acquisition Guidebook (focusing particularly on Section 4.5.7 Modeling and Simulation) [14], and online Continuous Learning Modules provided by the Defense Acquisition University's Continuous Learning Center [15], focusing on these two modules in particular:

- CLE 011 M&S for Systems Engineering
- CLE 023 M&S for Test & Evaluation

The project also will recommend updating the DoD Discovery Metadata Specification (DDMS) with the VV&A metadata for general use across the enterprise.

The M&S SC members represent the driving forces behind making the necessary changes to these various policy, guidance, and standards. Together they represent a unified front for M&S management across DoD.

The concept of operations in Figure 4 starts with a consumer's need to use M&S. The consumer employs the GIG to conduct a semantic search for VV&A information to locate resources that best meet requirements for the use of M&S. VV&A metadata transferred from the DVDT will be searchable in the M&S Resource Domain. Based upon the information retrieved from the M&S Resource Registry Domain, the consumer is exposed to information that can inform the decision to reuse a legacy M&S "as is," to modify a legacy M&S, or to build a new M&S. The producer uses the DVDT to document VV&A planning, implementation, and reporting. The DVDT uses XML source data to produce printable documents. When the producer initiates a VV&A project in the DVDT, VV&A metadata will be made available to the M&S Resource Registry Domain. When a VV&A document is finalized and approved, additional VV&A metadata will be made available to the M&S Resource Registry Domain.

4. DoD VV&A Documentation Tool

The DVDT is a technology development effort to automate the standard DoD VV&A templates that are captured in the DoD Standard Practice [2]. Automation of the templates will save users time by expediting the VV&A documentation production process and will ensure standardization of content and format across DoD and the Military Departments. Additionally, automation provides several other benefits:

- Ensure compliance with policy and guidance
- Guide users through the VV&A process
- Enable content consistency and completeness across all Communities enabled by M&S
- Facilitate and contribute to M&S reuse
- Provide quality and complete VV&A information to stakeholders faced with making decisions on the application of M&S results
- Provide standardized methods to communicate VV&A information at appropriate levels of detail

When the work to develop the standard templates was completed, efforts turned to identifying requirements for a DoD tool to automate the production of VV&A documents. Initially the requirements effort was led by the M&S Coordination Office (M&S CO) and now is part of this project.

Because the DVDT is a tool for use across DoD and the Military Departments, requirements for the tool reflect the needs of a broad population that cuts across all communities enabled by M&S. Examples of several high-level functional requirements include:

- web-enabled with Secure Socket Layer
- Common Access Card or Public Key Infrastructure certificate access to tool (for Government, Military, Civilian, and Contractors)
- private VV&A project management
- VV&A project owners grant access permission to other VV&A Team members
- log of users
- log of changes made to documents
- secure data storage
- requirements traceability across all documents
- produce four different documents
- common information update across all documents
- M&S Word-compatible, PDF and HTML formats
- automatic numbering of sections and subsections
- use of bold, italics, numbered and/or bulleted lists
- capability to insert graphics, images, and tables
- capability to send metadata about final approved documents to the M&S Resource Registry Domain.

Additionally, the DVDT offers a flexible experience. User will choose between a guided wizard interface and a "what you see is what you get" display. The tool also offers a context-sensitive help system that includes links to the appropriate policy and guidance documents.

The DVDT is being developed in conjunction with and will be compliant with the VV&A XML schema and VV&A ontology for M&S described in Section 5.

5. Structured VV&A Data

Effective data sharing requires a commonly understood representation of the data. In a web-based, network-centric architecture, data sharing through common representation is facilitated through the use of the Extensible Markup Language (XML) [16] and XML Schema language [17] standards. The XML Schema language is used to define the data structure and valid content of XML documents. Design and development of the DVDT includes design of an XML Schema description of information contained in the Defense Standard Practice for VV&A documentation [2]. The schema will describe data types and constraints suitable for ensuring the compliance of the XML documents created by the DVDT. The DVDT will be designed to read and write XML instance documents that validate[1] against this schema. Selected metadata about particular VV&A resources entered using the DVDT (resulting in XML instance documents) will be available to the M&S Resource Registry Domain.

Previous work on the prototype VV&A documentation tool is being leveraged to define the XML structures and content for the current project. The DVDT XML schema will be developed in accordance with current Department of the Navy XML Naming and Design Rules [18]. To promote visibility of this structural metadata, the schema will be posted to the DoD Metadata Repository for community reference and use. To be responsive to user needs, the project will coordinate with GIG M&S Community of Interest (COI) activities defining standards and best practices for metadata, data mediation and services, relating this work to VV&A processes, data and services as applicable.

The following paragraphs provide additional information about data sharing requirements in the GIG architecture. The Standardized Documentation for VV&A project will comply with data sharing policies for widest possible dissemination and utility of VV&A information of interest to the DoD M&S community.

5.1 VV&A Information on the GIG

> *The GIG is the globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, disseminating, and managing information on demand to warfighters, defense policymakers, and support personnel* [19].

In the GIG, information must be discoverable and accessible across the enterprise, dismantling traditional stovepipes that have restricted information exchange in the past. The DoD Net-Centric Data Strategy describes the vision for this net-centric environment and the data goals for achieving that vision through:

- ensuring data are visible, available, and usable when needed and where needed to accelerate decision-making;
- tagging all data (intelligence, non-intelligence, raw, and processed) with metadata to enable discovery of data by users;
- posting of all data to shared spaces to provide access to all users except when limited by security, policy or regulations; and
- advancing the Department from defining interoperability through point-to-point interfaces to enabling the "many-to-many" exchanges typical of a net-centric data environment.

The GIG provides enterprise services that enable data tagging, sharing, searching, and retrieving in support of the data strategy.

The Net-Centric Data Strategy also introduces management of data within communities of interest (COIs) or "collaborative groups of users who must exchange information in pursuit of their shared goals, interests, missions, or business processes and who therefore must have shared vocabulary for the information they exchange" [19].

COIs address organization and maintenance of data within their domains, while tagging the data in ways that make the data available for use within the COI and across COIs. COI-specific metadata structures provide an extended level of data definitions and structures. A community ontology will provide the data categorization, thesaurus, key words, and taxonomy. The COI-specific metadata structures and the community ontology will serve to increase semantic understanding and interoperability of the community data.

The goal of posting data to shared spaces uses metadata registries and metadata catalogs. A metadata registry contains information describing structure, format, and definitions of data. DoD has established the DoD Metadata Registry, containing document formats, interface definitions, exchange models used by systems, messaging formats, symbology, ontologies, and transformation services. The registry currently incorporates the DoD XML Registry, the Defense Data

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[1] "Validate" here is used in the XML sense of ensuring that the structure and content of an XML instance document conforms to the specifications given in the associated XML schema document(s).

Dictionary System, and commonly used data reference sets. A metadata catalog contains instances of metadata associated with individual data assets. In XML parlance, the metadata registry contains XML schema files and the metadata catalog contains XML instance documents conforming to the respective schema files.

To further promote data discovery, DoD created the DDMS. The DDMS "defines metadata elements for resources posted to community and organizational shared spaces…The DDMS specifies a set of information fields that are to be used to describe any data or service asset that is made known to the enterprise, and it serves as a reference for developers, architects, and engineers by laying a foundation for Discovery Services" [20]. Figure 6 provides an overview of the categories of metadata specified in the DDMS.

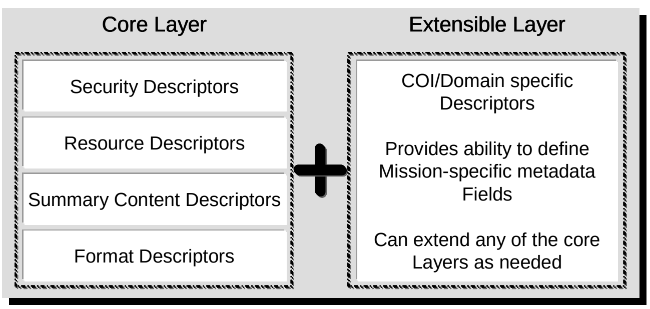

Figure 6. DoD Discovery Metadata Specification Overview (from [20])

This project will support the goals of the Net-Centric Data Strategy with respect to data relating to VV&A of M&S resources. Additional discussion of how the project will address the goals of data visibility, discovery, and understandability is provided in the following.

5.2 Visibility, Discovery, Understandability

To promote discovery, this project will leverage the DDMS XML vocabulary through reference to the DDMS namespace. Another effort is in progress to identify DDMS metadata applicable to DoD M&S products and resources and to identify additional metadata needed for M&S purposes that will supplement DDMS requirements (and may be proposed as extensions to DDMS). Also, that work will be leveraged to identify DDMS and M&S metadata that can be reused in the DVDT XML schema and in the document instances conforming to that schema. Finally, the project will also determine if certain metadata specific to VV&A documentation should be proposed as extensions to the DDMS for general use across the enterprise.

To further promote the Net-Centric Data Strategy goal of enabling the data to be understood, this project will explore application of other web-based standards for describing information. Tim Berners-Lee's vision for the World Wide Web is creation of a web of knowledge, termed the Semantic Web [21]. This is being addressed through research and development of standards that provide representation of stronger semantics in web-based information, in line with the Net-Centric Data Strategy goal of enabling data to be understandable by users and applications, both structurally and semantically. Current and emerging Semantic Web standards include the Resource Description Framework (RDF), RDF Schema, Web Ontology Language (OWL), and Semantic Web Rule Language (SWRL), among others.

5.3 Strong Semantics

For future growth in automation of VV&A processes and information, the project will develop a formal ontology that can be employed by software and humans attempting to discover M&S components/resources and to assess suitability of those components/resources for the desired purpose. We will investigate the current state of defined VV&A taxonomies, processes, and artifacts to design an initial VV&A ontology describing important concepts, properties, relationships, constraints, and business rules. The ontology will be developed using Web Ontology Language (OWL) and other Semantic Web standards as deemed appropriate.

The VV&A ontology work will establish a technical case for application of formalized semantics relating to VV&A processes and records. The formalisms will include the above metadata (XML schema) describing M&S data and products; but will extend the data modeling to provide deeper description of the concepts. The work will review prior VV&A research and development to develop an initial taxonomy of M&S artifacts and VV&A processes and artifacts (for example, see [22] and [23]). The taxonomy will then be extended to include properties that reflect interrelationships across classes or categories of concepts. For example, a taxonomy of M&S systems may classify systems by use as training or analysis systems, with possibly a third classification for systems that can be used for both purposes. However, an M&S system accredited for training may also be accredited for analysis purposes, but only under certain constraints and conditions in its employment.

The project will design and develop an ontology expressing VV&A information established in VV&A processes and M&S documentation. Previous markup language work and the Defense Standard Practice [2] provide an excellent starting point for defining classes and properties in the ontology. Concentration will be on classification schemes that will support semantic discovery of VV&A metadata describing M&S resources as well as providing an ability to perform logical inferences on the information to relate VV&A information to user or system requirements in obtaining and using needed M&S resources. In addition to the ontology itself, the work will produce a technical report on the ontology design, including design decisions and trade-offs made during the effort.

More expressive ontologies can describe not only the classes and their properties relevant to VV&A information, but relationships across classes that cannot be represented in a strict hierarchical structure as defined by XML Schema. In the literature on ontology design, the importance of determining the domain and scope of the ontology, to include identification of questions that a knowledge base built from the ontology should be able to answer, is emphasized [24]. This level of semantic sophistication will be needed to enable humans and software to better access and employ VV&A information about M&S resources as the community moves toward GIG service-oriented and net-centric architectures.

6. Summary

This paper updated the Systems Engineering Community about the DoD M&S Project titled, "Standardized Documentation for VV&A". It provided information on the development of standardized content and format requirements for four core VV&A documents, the technology development efforts to automate those templates to ensure standardization across the DoD and Military Departments, and the work underway to identify VV&A metadata that will enable the sharing of information across all M&S Communities via GIG service-oriented and net-centric architectures. Additionally, gaps, objectives, and actions from the Common and Cross-Cutting Business Plan and the DoD Acquisition M&S Master Plan were identified. Finally, a project management overview including a concept of operations was provided.

If you would like to become a DVDT beta tester or use the DVDT to support a VV&A project, you can contact any one of the authors to obtain more information.

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MARCY STUTZMAN provides management and technical services to the NMSO VV&A Lead as an Operations Research Analyst for Northrop Grumman. She served in the U.S. Army as a Senior Intelligence Research Analyst, Cryptologic Language Analyst, Reporter, and Voice Interceptor with five years duty at the National Security Agency. She is a member of the NDIA M&S Committee, the Simulation Interoperability Standards Organization, and the IEEE Standards Association. She has a Bachelor's degree from Indiana University and has provided M&S and VV&A support to the DoD, Army, and Navy since 1990.

Aeronautical Systems Center

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Integrated Risk Management (IRM) Revitalization

Oct 07

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Agenda

- **IRM Process Background**
- **Integrated Risk Assessment Overview**
- **IRM Improvement Efforts**
- **Linkage with Air Force level efforts**
- **Status of Risk Management Actions**

IRM Process Background

- IRM survey revealed confusion in Acquisition Weapon System (WS) Program Offices
  - Poor results
  - Lack of understanding
- Inconsistent process across WS life cycle
  - Varying levels of rigor
  - Process and knowledge base not documented across phases

IRM Process Background

- **Pockets of excellent work**
  - **ACE pre-contract award risk workshops**
  - **Engineering (EN)-facilitated Integrated Risk Assessments (IRAs)**
  - **Finance (FM)-executed schedule and cost risk assessments for annual Program Office Estimate (POE)**
- **Efforts not well coordinated and IRA execution was not prioritized**
- **IRM joint process between Engineering and Finance. Program management not involved.**

Integrated Risk Management

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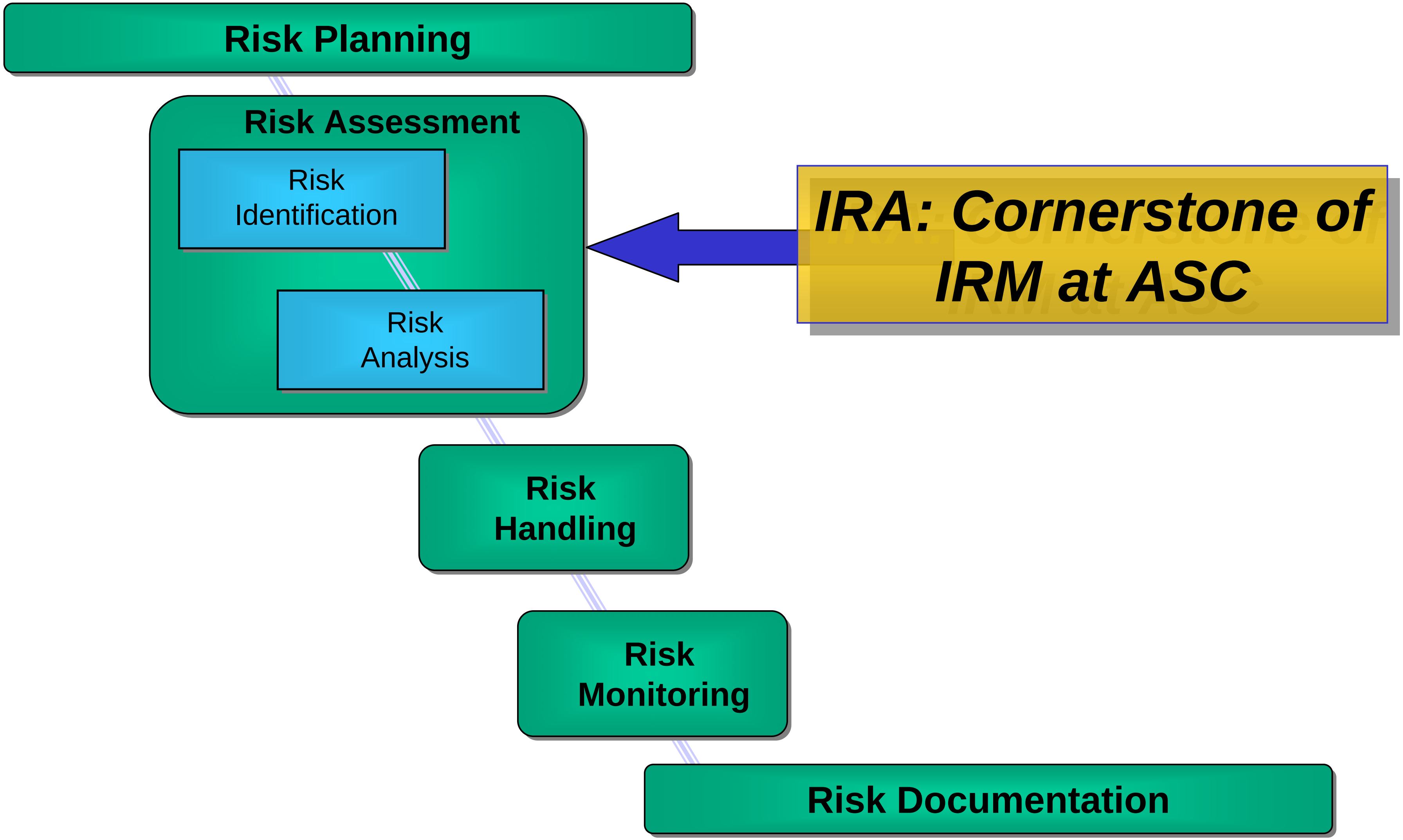

What is an Integrated Risk Assessment?

- **Identifies and analyzes program risks against performance, schedule and cost objectives**
  - **Reveals impacted resources**
    - **Performance - Schedule - Cost**
  - **Develops more realistic schedule and cost estimates via Monte Carlo simulations with revealing 90% confidence interval**
  - **Should coincide with the annual life cycle Program Office Estimate (POE)**
- **Two Segments**
  - **Risk identification (qualification – ASC/AE and FM)**
  - **Evaluation and analysis (quantification – ASC/FM)**

Risk Assessments

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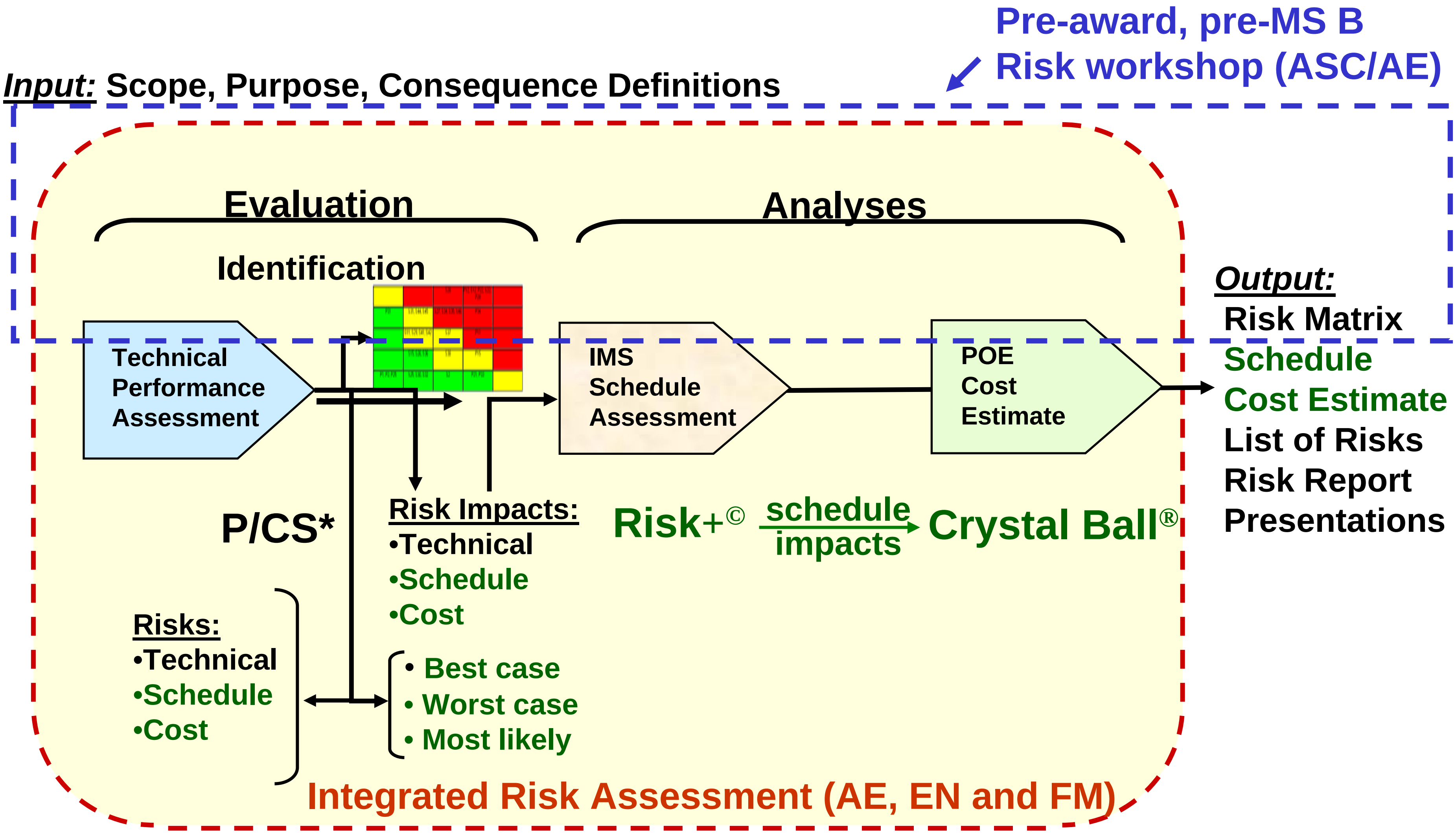

Outputs from both venues lead to more effective risk handling and monitoring

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IRM Process Background, cont

- **ASC Commander Policy**

  "Complete an annual IRA, ideally in conjunction with the annual program life cycle cost estimate (POE) to ensure risks/risk handling are quantified and appropriately budgeted."

- **Policy is not followed**
  - **Insufficient manpower to execute policy**
    - **Both in wings and staff to support**
  - **No tracking of IRA activities**
- **Inconsistent IRA and POE requirements**
  - **POE policy allows requirement waiver for programs meeting certain criteria**
  - **No similar policy for IRAs**

IRM Improvement

- **Risk Staff: program management, engineering, and financial management began risk management process advancement endeavors**
- **ASC Leadership process improvement offsite (AFSO21/Balanced Scorecard) identified two risk management initiatives**
- **Consolidated staff and Balanced Scorecard initiatives into single effort**
  - **"Improve risk vision, advocacy and processes"**

AF-Level Process Improvement

- **Develop and Sustain Warfighter Systems (D&SWS) Process Improvement Team**
  - **Continuous Capability Planning Sub-Process Team**
    - **Recommend process improvements, initiatives and metrics**
  - **RM is initiative due to high-level interest**
    - **Labeled as “enduring process” throughout life cycle**
    - **Objective to standardize processes, definitions, tools**
    - **SAF ACE identified as process owner and Implementation Team Lead**

Risk Management Improvement Completed Actions

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- **Refine organizational responsibilities**
  - **AE/EN/FM joint owners of IRM process**
  - **AE designated as ASC risk management lead**
  - **EN IRM Tech Expert moved to AE to increase effectivity, efficiency, and consistency**
- **Ensured risk aspects of Probability of Program Success (PoPs) assessment tool was incorporated into risk assessments**
- **Ensure uniform risk training across ASC**

Risk Management Improvement Current Action

- **Improving efficiency and effectiveness of IRA process**
  - **Align need for high-confidence programs with manpower limitations**
  - **Prioritize programs for IRAs beginning Winter 07**
- **Beta test using FM's Apr 06 PoE waiver process data to determine applicability to IRA waivers**
  - **Updated data with Wing Commanders and Directors of Engineering**
  - **Determined PoE waiver good starting point for IRA waiver or tailored IRA**

POE Waiver Criteria

- **ACAT III IRA Waiver Process**
  - **Low cost/risk**
  - **Cost Contract**
  - **Firm Fixed Price $\leq$ \$50M**
  - **Time and Materials contract**
  - **Level of Effort programs**
  - **Programs in last year of effort**
  - **Short duration programs (1 year or less)**

Risk Management Improvement Current Actions, cont

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- Complete waiver process of ACAT III programs
- Prioritize remaining programs (ACAT I, II, and required ACAT III)
  - Event driven rather than annual
  - Emphasize high risk and new programs
- Develop schedule for IRA execution
- Update ASC/CC IRM policy

IRA waiver does not eliminate need for day-to-day risk management

IRA Prioritization Schedule

- **Emphasis new programs**
- **Ensure IRA completed early in program**
  - **Prior to PDR**
  - **Complete early assessment of performance, schedule and cost risks and impacts. And Maintain!**
  - **Establish robust risk management practices at the onset of the program**

Risk Management Improvement Ongoing Actions

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- Improve and document total program Life Cycle risk process
- Ensure consistency with DoD, DAU, AFIT, CSE, and INCOSE
- Create ASC-wide risk IPT with reps from AE/EN/FM and each WS program office
- Increase knowledge and awareness of risk management
- Develop cadre of trained facilitators
- Evaluate adequacy of available manpower resources

Comments/Questions?`

Backup

IRM Survey Results

- **IRM survey revealed confusion on requirements in Wings**
  - **Poor results**
  - **Lack of understanding**
- **Inadequate manpower in Wings and staff organizations to support IRA policy**
- **Disconnects between annual Program Office Estimate (POE) and IRA policy letters**
  - **IRA and POE requirements are linked**
    - **Results of IRA input to POE**
    - **Can complete IRA without POE; however, POE is not considered complete without IRA**
    - **Identification of risks alone does not constitute an IRA**
  - **Current policy letters are out of sync**
    - **POE policy allows waiver under certain conditions**
    - **IRM policy allows for no IRA waiver**

Risk Workshop vs. IRA

- **Significant difference in AE Risk pre-award workshops and Facilitated IRA**
  - **1 day vs 2 weeks**
  - **Focus primarily on high level programmatic risk assessment vs total risk assessment (cost, schedule, performance)**
    - **Shallow dive vs deep dive**
    - **Risk of getting on contract vs total program risks (cost, schedule, performance)**

Technical Performance Assessment

- **Insert description**

Schedule Risk Analysis (SRA)

- **Risks identified during IRA are quantified in and added to the Integrated Master Schedule (time)**
- **Accomplished for critical path elements (time constraints may preclude expanding SRA to other elements)**
- **Best case, most likely and worst case results input to Risk+ schedule assessment tool, Monte Carlo analysis run**
- **Results in additional time (hrs, months, etc.) and dollars needed for higher confidence schedule**

Cost Risk Analysis (CRA)

- **Risks identified during IRA are quantified in and added to the cost estimate (dollars)**
- **Accomplished at lowest WBS element appropriate**
- **Best case, most likely and worst case results input to Crystal Ball cost assessment tool, Monte Carlo analysis run**
- **Results in additional costs required for higher confidence estimate**

Risk in the Acquisition Life Cycle

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A | B | C

Concept Refinement	Technology Development	System Development & Demonstration	Production & Deployment	Operations & Support
Concept Decision		Design Readiness Review	FRP Decision Review	

ASC/AE-facilitated Risk Workshop*

Pre-award, Pre-MS B
Output: Risks identified and plotted on 5x5 matrix
Duration: 1-3 days
Location: ASC/AE facility
Involves Program Office, user, contractor (if sole source)
Technical Analysis accomplished on ability to execute, schedule analysis accomplished on getting on contract, not program's IMS
ASC/CC Policy: N/A

*Can occur at any time throughout the life cycle in conjunction with contractual actions (pre MS B, LRIP, pre MS C, etc)

ASC/EN- and FM-facilitated Integrated Risk Assessment

Post-award, annual requirement throughout acquisition life cycle
Output: Risks identified and plotted on 5x5 matrix, risk impacts quantified, risk impacts analyzed via statistical analysis, additional time and budget required to complete program calculated and added to IMS and POE
Duration: 2 weeks not including prep time and post-workshop analysis time
Location: Offsite
Involves Program Office (all functionals), contractors, subs, users, subject matter experts, advisors
Technical, Schedule and cost analyses accomplished against ability to meet contract requirements
ASC/CC Policy: 05-004

Day-to-day risk management should occur jointly with the contractor

Recent Policy Directives

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- **ASC/CC Policy Memo 05-014: PEO Policy for Systems Engineering**
  - **Requires more rigorous systems engineering with risk management as a key aspect**
  - **https://www.asc.wpafb.af.mil/policy_letters/policymemo05-014.pdf**
- **ASC/CC Policy Memo 05-003: Policy on Life Cycle Estimates**
  - **Programs to provide Life Cycle Cost Estimates including integrated risk assessments reflecting 90% confidence of meeting our commitments**
  - **https://www.asc.wpafb.af.mil/policy_letters/policymemo05-003.pdf**

Recent Policy Directives

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- **ASC/CC Policy Memo 05-004, Policy on Integrated Risk Management**
  - **Requires annual Integrated Risk Assessment**
  - **https://www.asc.wpafb.af.mil/policy_letters/policymemo05-004.pdf**
- **ASC/CC Policy Memo 06-007, Policy on Environment, Safety and Occupational Health (ESOH) Programmatic Risk Management Integration into Acquisition and Systems Engineering Processes**
  - **Requires annual programmatic ESOH risk assessments in conjunction with the IRA**
  - **https://www.asc.wpafb.af.mil/policy_letters/policymemo06-007.pdf**

Sample Risk Definitions

Tailorable Risk Grid

Consequence → Higher

Probability → Higher

	Negligible (N)	Minor (M)i)	Moderate (Mo)	Serious (S)	Critical (C)
5 91-100%	Cost = < 1% Variance Schedule = < 1 Wk Var Technical = Meets Performance	Cost = 1-5% Variance Schedule = 1-4 Wk Var Technical = Minimal Impact to Performance	Cost = 6-10% Variance Schedule = 5-8 Wk Var Tech/Performance = Acceptable Work-around	Cost = 11-20% Variance Schedule = 9-12 Wk Var Tech/Performance = Degraded	Cost = > 20% Variance Schedule = > 12 Wk Variance Tech/Performance = Impacted
4 61-90%	Cost = < 1% Variance Schedule = < 1 Wk Var Technical = Meets Performance	Cost = 1-5% Variance Schedule = 1-4 Wk Var Technical = Minimal Impact to Performance	Cost = 6-10% Variance Schedule = 5-8 Wk Var Techl/Performance = Acceptable Work-around	Cost = 11-20% Variance Schedule = 9-12 Wk Var Tech/Performance = Degraded	Cost = > 20% Variance Schedule = > 12 Wk Variance Tech/Performance = Impacted
3 41-60%	Cost = < 1% Variance Schedule = < 1 Wk Var Technical = Meets Performance	Cost = 1-5% Variance Schedule = 1-4 Wk Var Technical = Minimal Impact to Performance	Cost = 6-10% Variance Schedule = 5-8 Wk Var Tech/Performance = Acceptable Work-around	Cost = 11-20% Variance Schedule = 9-12 Wk Var Tech/Performance = Degraded	Cost = > 20% Variance Schedule = > 12 Wk Variance Tech/Performance = Impacted
2 11-40%	Cost = < 1% Variance Schedule = < 1 Wk Var Technical = Meets Performance	Cost = 1-5% Variance Schedule = 1-4 Wk Var Technical = Minimal Impact to Performance	Cost = 6-10% Variance Schedule = 5-8 Wk Var Tech/Performance = Acceptable Work-around	Cost = 11-20% Variance Schedule = 9-12 Wk Var Tech/Performance = Degraded	Cost = > 20% Variance Schedule = > 12 Wk Variance Tech/Performance = Impacted
1 0-10%	Cost = < 1% Variance Schedule = < 1 Wk Var Technical = Meets Performance	Cost = 1-5% Variance Schedule = 1-4 Wk Var Technical = Minimal Impact to Performance	Cost = 6-10% Variance Schedule = 5-8 Wk Var Tech/Performance = Acceptable Work-around	Cost = 11-20% Variance Schedule = 9-12 Wk Var Tech/Performance = Degraded	Cost = > 20% Variance Schedule = > 12 Wk Variance Tech/Performance = Impacted

Legend: Low Medium High

Integrated Risk Management Survey

- **Does your program have a Risk Management Plan (RMP)?**
- **Does your program have an Integrated Master Schedule (IMS)?**
- **Does your program have a current Integrated Risk Assessment (IRA)?**

Survey Top level Findings

- **Lack of common understanding of requirements, policy and utility of these items**
  - **Many have "never heard of the IRA process"**
  - **Many believe "I've got Risk covered"**
    - **I did an AE Risk Workshop**
    - **I've got my risks plotted on a matrix!**
    - **Yes I had an IRA. It's scheduled next year!**

- **Organizations lack training in RMPs, IMSs, and IRAs**

- **Programs are not following current ASC IRM policy relating to RMP (64%), IMS (67%), IRA (56%)**
  - **Confusion on how to answer questions**
  - **RMP and IMS stats seem to be inaccurate, IRA stat is inaccurate**

Program Risk Not Adequately Understood or Managed at ASC

D&SWS Integrated "To Be"

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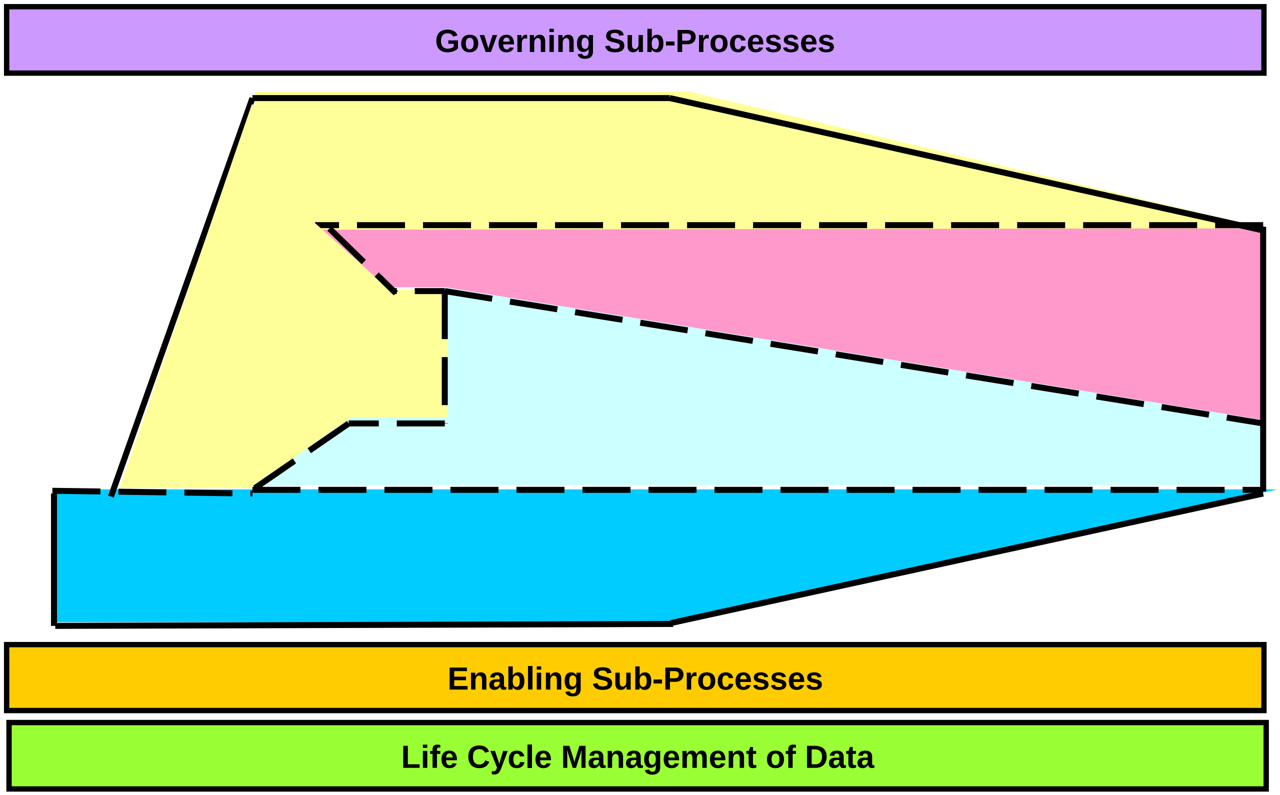

Attributes

- Minimize Total Ownership Costs
- Capability Focus Throughout Life Cycle
- High Confidence Programs
- Transition Mature Technology
- Tight Stakeholder Partnerships
- Right Data for Right Decision at Right Time

Enduring Processes

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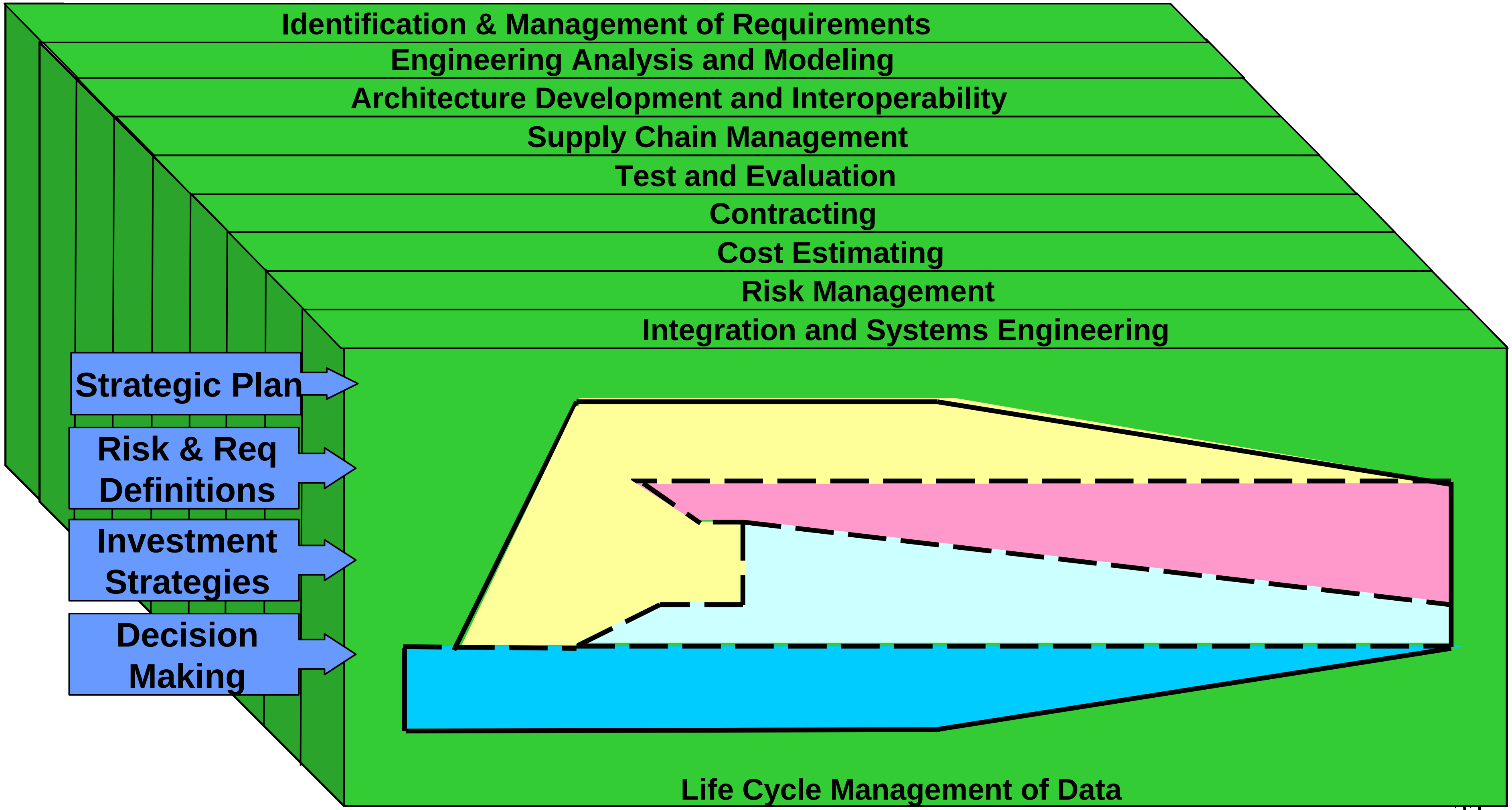

Air Force Modeling & Simulation Training Toolkit *(AFMSTT)*

Advanced Net Centric Simulation for Aerospace Command & Control

Ms. Kim Kendall
AFMSTT Program Manager
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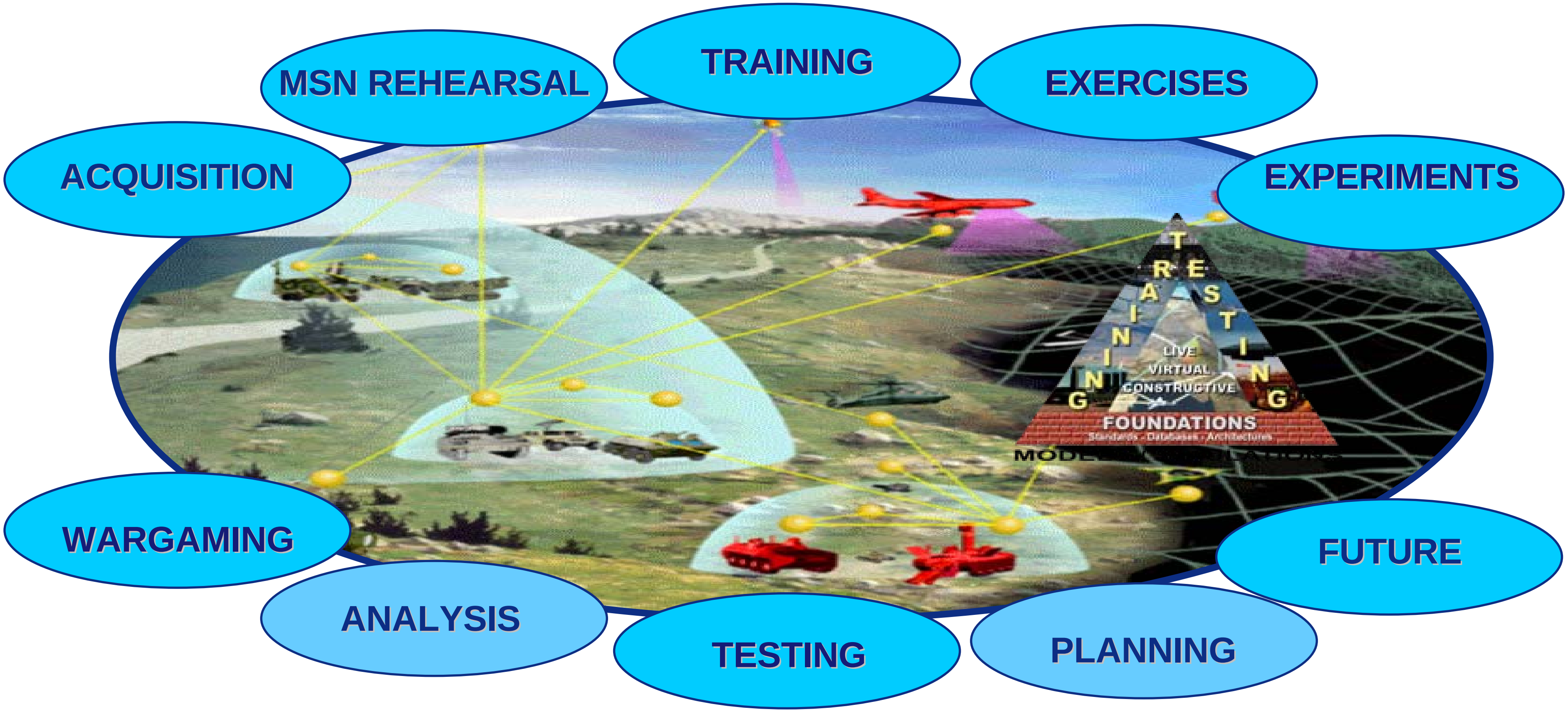
Hanscom AFB, MA

24 October, 2007

Overview

- Winning the GWOT - M&S a Force Multiplier
- Why Netcentric Operations?
- Moving to the Global Information Grid
- Building a Foundation for Netcentric Operations
- Systems Engineering “Best Practice” Approach

AFMSTT Supported Disciplines



What is achieved from simulation?
1) Joint Readiness 2) Distributed Ops 3) Safer Environment 4) Lower Cost

Win the GWOT
AFMSTT a Force Multiplier

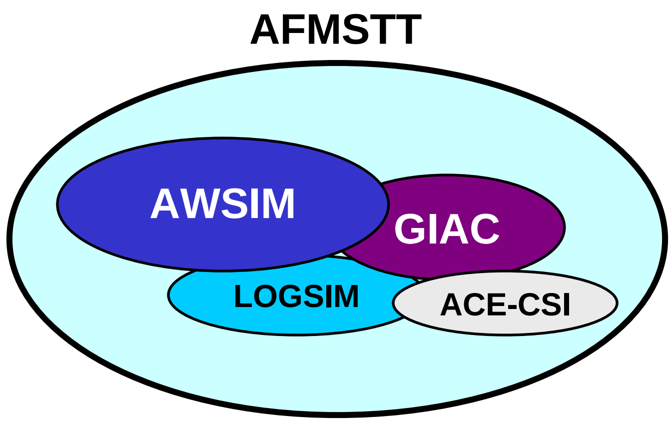
- **Realistic/Consistent Training**
  - **Integrated Live, Virtual, Constructive**
  - **Dynamic, interactive planning & decision support**
  - **M&S transparent to training audience**
- **Mission Rehearsal**
  - **On demand, on location training**
  - **Flexible scenario generation**
- **Risk Reduction**
  - **Safer environment for Warfighter**
  - **Interact with real world C2 systems**

AFMSTT supported 14 major and 26 associated test/integration events last year!

Constructive Air Power Simulation Supporting Joint/Service Battlestaff

Exercise Support
- Ulchi Focus Lens
- BLUE FLAG
- Austere Challenge
- Joint RED FLAG
- Terminal Fury
- Ardent Sentry

Experimentation Support
- Joint Expeditionary Force Experiment (JEFX)
- Coalition Warrior Interoperability Demo (CWID)



Mission Rehearsals
- Unified Endeavor
- Global Thunder

Acquisition Support
- TBMCS Testing
- AF-ICE

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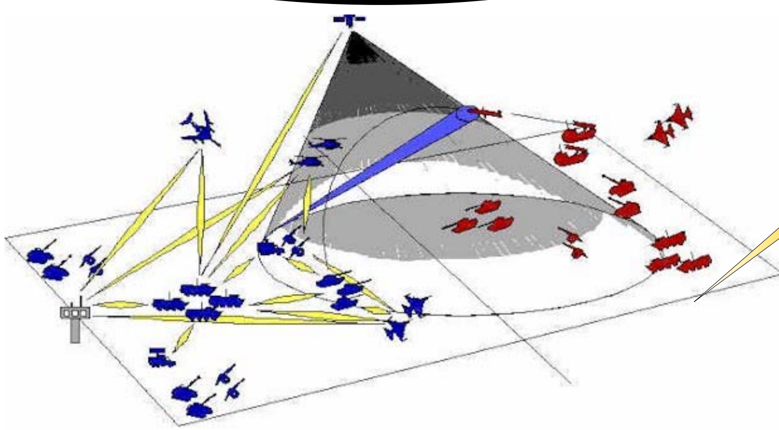
Why Net-Centric Operations?

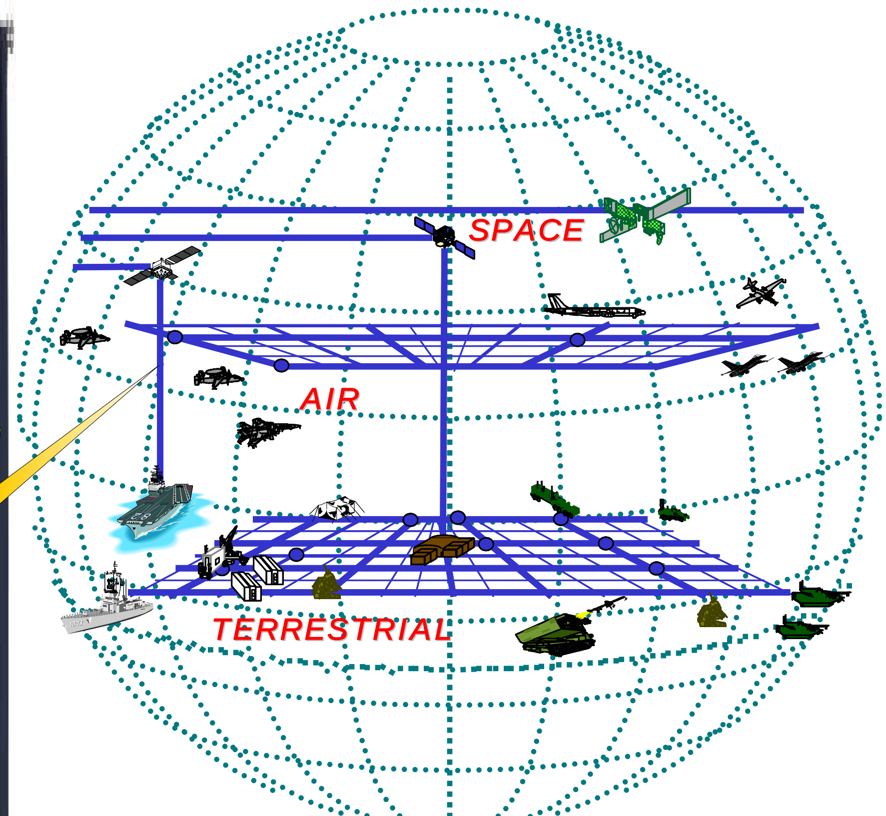
- **Net-Centric Operations is the ability to:**
  - **Rapidly collect and share appropriate data in a collaborative environment**
  - **Recognize significant data**
  - **Understand the data**
  - **Efficiently make better-informed decisions by yourself or in a collaborative environment**
  - **Rapidly act (or not act) on decisions**
  - **Rapidly get feedback**
  - **Understand services available**
  - **Efficiently use those services (or capabilities)**
  - **Efficiently provide services for others in a manner consistent with your mission**

Derived from: Network Centric Warfare, Alberts, Garstka, Stein

AFMSTT with the GIG

AFMSTT
- Real C2 Data and Interfaces
- Simulated Air Battlespace Data





Integrated M&S and C2 Environments that support Net Centric Operations (NCO)

Moving to Netcentricity using NESI tenants

Net-centric Enterprise Solutions for Interoperability (NESI)

- **Implementation guidance to facilitate the design, development and usage of information systems for net-centric warfare**
- **Effective for migrating deployed applications using a phased approach**
- **Based on industry best practices**
- **Cross-Service effort between Air Force (ESC) and Navy (PEO C4I & Space)**
    - **Army & DISA participated informally**

Systems Engineering "Best Practices" Approach

- Incremental Approach
  - No wholesale re-write of code base
  - No impact to current operations tempo/event support

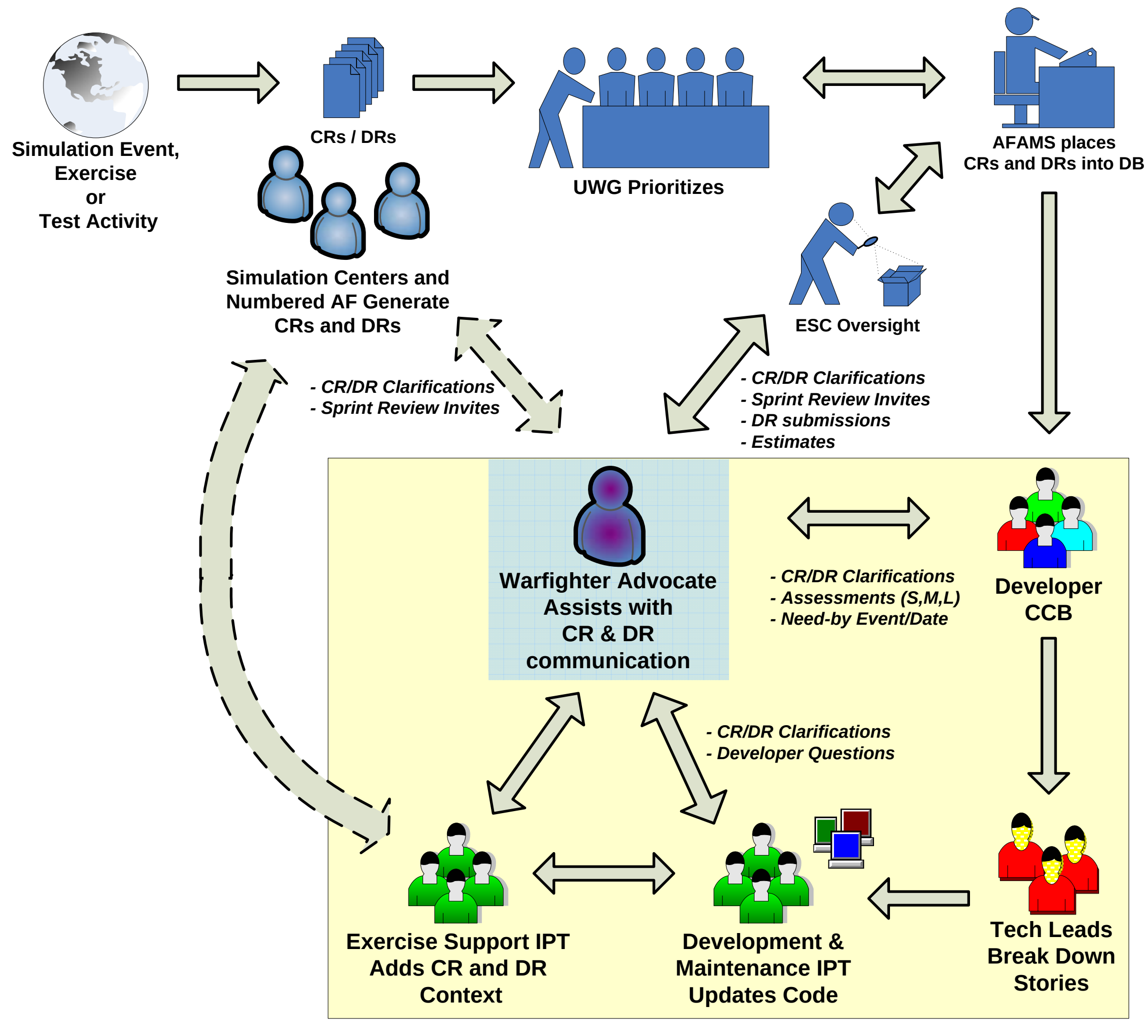
- Collateral requirements
  - No impact to toolkit performance
  - No increase in AFMSTT footprint

Systems Engineering "Best Practices" Approach (Cont)

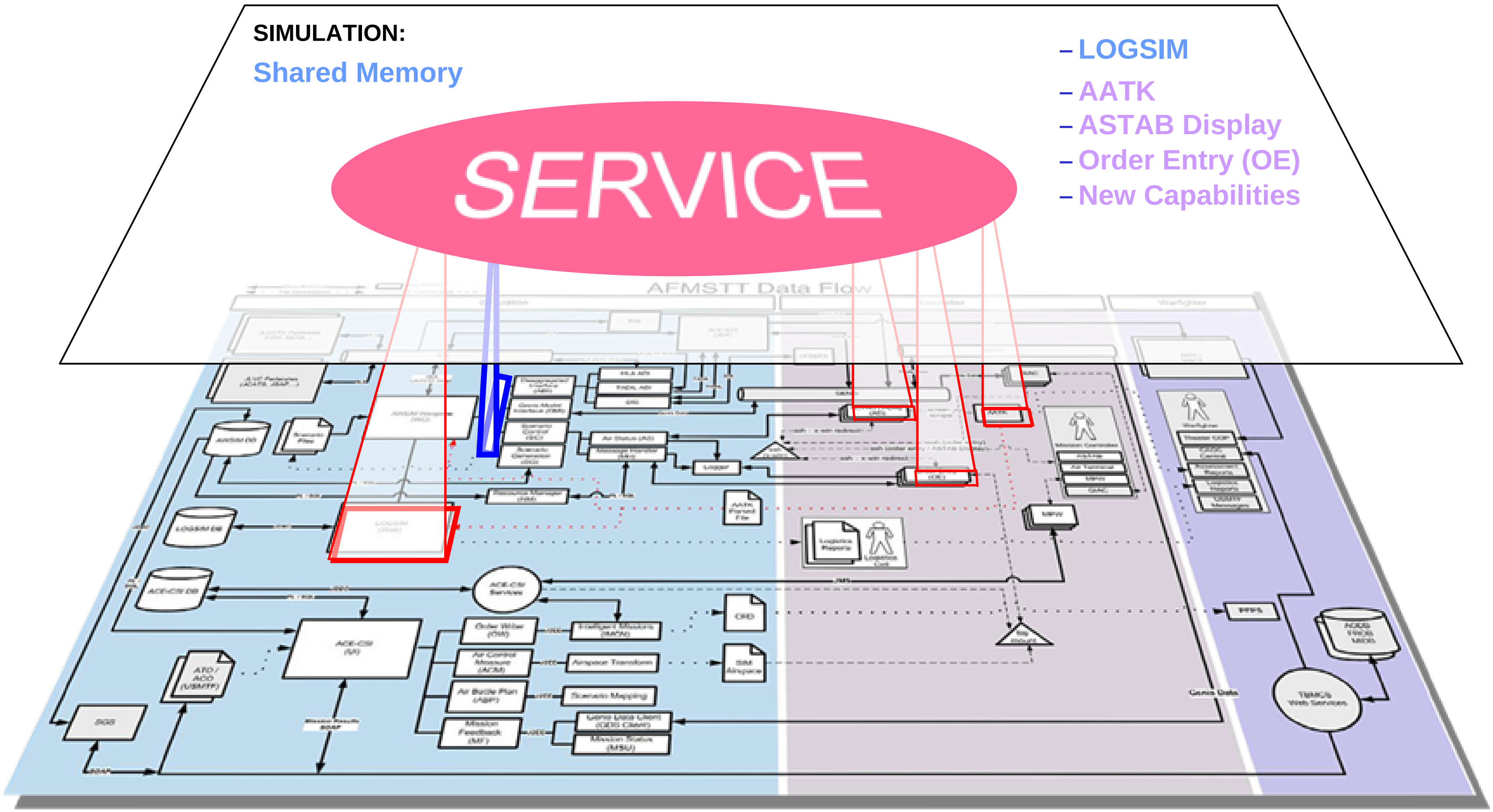
- Architecture requirements
  - Integrate within Current Acquisition Framework
  - Design for Location Independence
  - Increase Collaboration
  - Separate business, data and presentation logic
  - Service Oriented Architecture (SOA)

Proven, Effective Techniques…Bringing legacy systems into the 21st Century

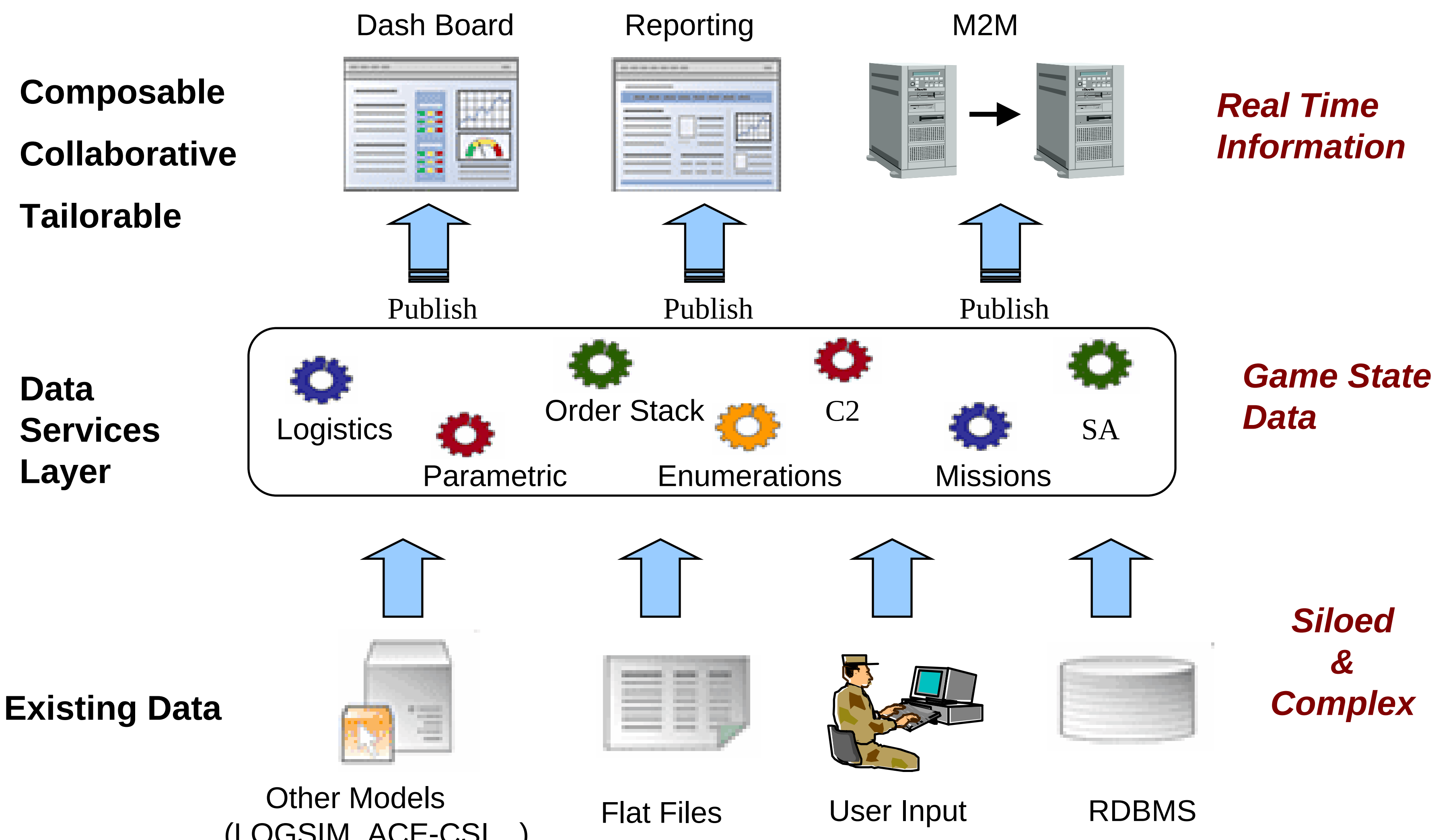
Agile Acquisition Development Framework



Exposing Data



Building a Foundation for Netcentric Operations



Benefits/ New Possibilities

An AFMSTT data service will promote…

- **Access to virtual battlespace information using established commercial standards**
  - **SOAP/WSDL**
  - **REST**
  - **XML message protocol**
- **Improved Model Controller Efficiency**
- **Provides Integration Engine for LVC environment**
- **Enhanced capability for analysis/agile acquisition**

Benefits/ New Possibilities

and unlock untapped investment!

- **Easy integration of new capabilities as training missions change**
  - **Flexible, Adaptive Functionality Reuse**
- **Location Independence**
  - **Reduced set-up time & travel costs**
  - **Collaborative Event Planning/Managing**
  - **Reachback to center of excellence**

FASTER, CHEAPER, LESS RISK

New/Emerging Netcentric Capabilities

- Enhanced Reachback
  - 24X7 Help Desk
  - FAQ Portal
- Re-architected Distributed Mission Planning Workstation
  - Java Message Service replaced direct queries
  - Preserved core business logic
  - Solution was transparent to end users
- JTEN node connection from ESC integration facility

Providing Capability to the Warfighter

Summary

- M&S provides a low cost option for validating war fighter missions pre-execution, real world systems, and a broad array of AF disciplines (acquisition, test, etc)
- Adaptation to changing GWOT mission is critical
  - Modernization can be achieved through sensible "localized" wins focused on scaling in a net-centric way
- Provides continued innovation in netcentric capabilities to provide relevant capability to the user anytime, anywhere

Bringing a very valuable legacy simulation into the 21st Century !!

Questions?

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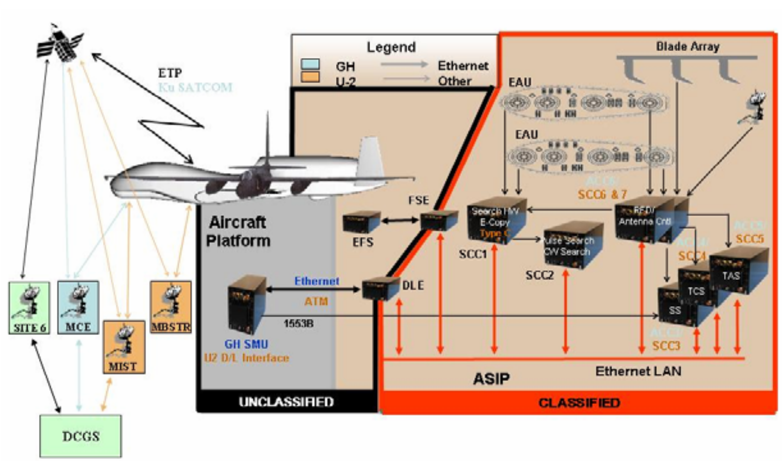
Airborne Signals Intelligence Payload (ASIP) Integrated Risk Management

Presented to:
10th Annual Systems Engineering Conference
24 October 2007



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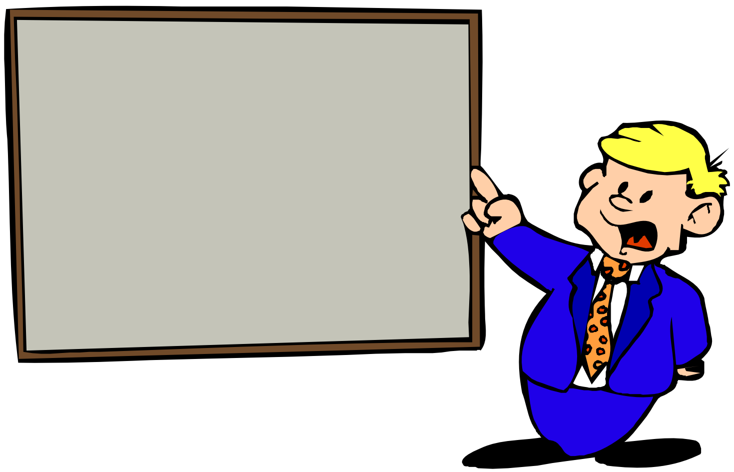
Outline

- **ASIP Program**
- **ASIP System of Systems**
- **Risk Terminology**
- **ASC/EN SE Tool Set**
- **Integrated Risk Management**
- **Integrated Risk Assessment (IRA)**
- **ASIP IRA Risk Summary**
- **ASIP SoS Risk Management**
- **ASIP Risk Management Model**
- **Best Practices**
- **ASIP Risk Management Results**
- **Risk Metrics**
- **Take Aways**



Airborne Signals Intelligence Payload (ASIP) Program

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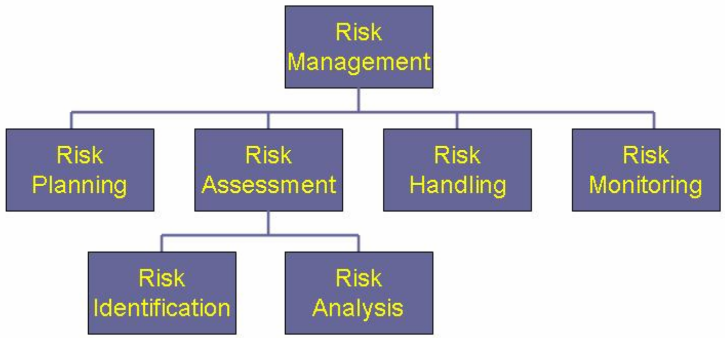
- **USAF ACAT II SDD program under OSD T&E oversight**
  - **Currently in developmental flight test on U-2**
- **Payload collects & processes COMINT, ELINT & special signals targets**
- **Managed as a system-of-systems (SoS)**
  - **Integrated master schedule**
  - **Interface control**
  - **RISK MANAGEMENT**



ASIP System of Systems*

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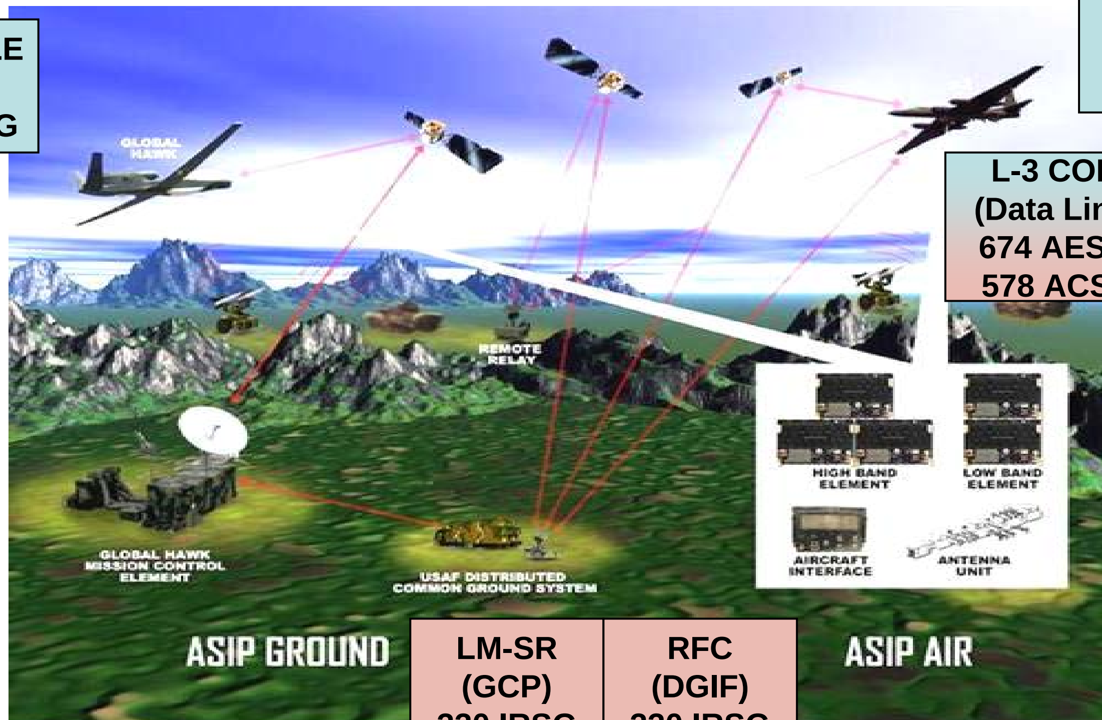


NG - HALE (GH) 303 AESG

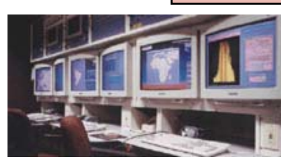
LM-A (U-2) 674 AESF

L-3 COM (Data Link) 674 AESF/ 578 ACSS

NG - ESL (Sensor) 659 AESS

LM-SR (GCP) 330 IRSG

RFC (DGIF) 330 IRSG



* **Managed at WPAFB**

Managed at WRALC

"… A system of systems is a set or arrangement of interdependent systems that are related or connected to provide a given capability. The loss of any part of the system will significantly degrade the performance or capabilities of the whole…." (DAG 1.2.1)

Terminology

- **Risk:** A negative, <u>future</u> event that may occur, causing an execution failure in the program and you are able to estimate the probability and consequence (<u>between 0-100% probability of occurrence</u>)
- **Issue:** A negative, <u>future</u> event that is certain to occur and will have a negative impact on the program (<u>100% probability of occurrence</u>)
- **Problem:** A negative event that has <u>already occurred</u> (a risk that has come to fruition)
- **Concern:** A negative, future event that may occur, but you have insufficient information to quantify the probability and consequence

ASC/EN SE Tool Set

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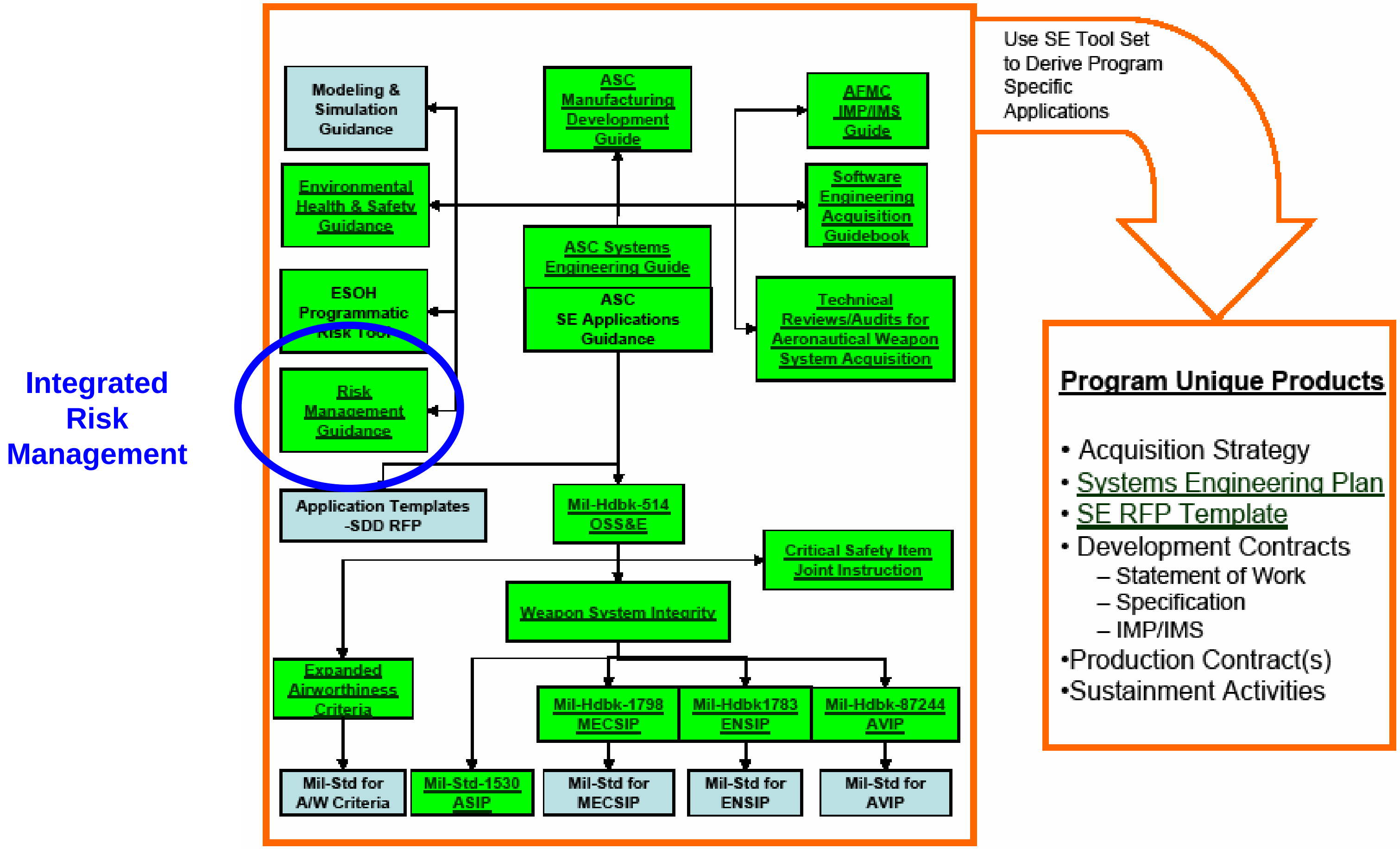
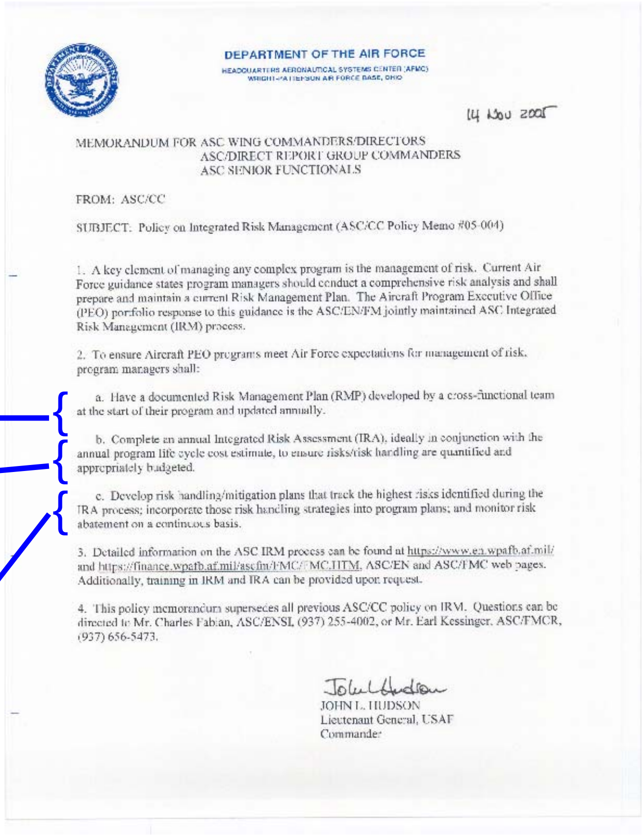


"… SE tools and processes available to assist program teams in structuring a program specific SE approach …."

Integrated Risk Management (IRM)

Dominant Air Power: Design For Tomorrow…Deliver Today

- **IRM is preferred method at ASC**
  - **Part of acquisition strategy**
  - **Joint government/industry**
  - **Cross-functional**
  - **Single program risk deck**
  - **Documented Risk management plan**
  - **Integrated Risk Assessment (IRA) accomplished in conjunction with annual life cycle cost estimate**
  - **Incorporate mitigation into program plans**



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

14 Nov 2005

MEMORANDUM FOR ASC WING COMMANDERS/DIRECTORS
ASC/DIRECT REPORT GROUP COMMANDERS
ASC SENIOR FUNCTIONALS

FROM: ASC/CC

SUBJECT: Policy on Integrated Risk Management (ASC/CC Policy Memo #05-004)

1. A key element of managing any complex program is the management of risk. Current Air Force guidance states program managers should conduct a comprehensive risk analysis and shall prepare and maintain a current Risk Management Plan. The Aircraft Program Executive Office (PEO) portfolio response to this guidance is the ASC/EN/FM jointly maintained ASC Integrated Risk Management (IRM) process.

2. To ensure Aircraft PEO programs meet Air Force expectations for management of risk, program managers shall:

a. Have a documented Risk Management Plan (RMP) developed by a cross-functional team at the start of their program and updated annually.

b. Complete an annual Integrated Risk Assessment (IRA), ideally in conjunction with the annual program life cycle cost estimate, to ensure risks/risk handling are quantified and appropriately budgeted.

c. Develop risk handling/mitigation plans that track the highest risks identified during the IRA process; incorporate those risk handling strategies into program plans; and monitor risk abatement on a continuous basis.

3. Detailed information on the ASC IRM process can be found at https://www.en.wpafb.af.mil/ and https://finance.wpafb.af.mil/ascfm/FMC/FMC.HTM, ASC/EN and ASC/FMC web pages. Additionally, training in IRM and IRA can be provided upon request.

4. This policy memorandum supersedes all previous ASC/CC policy on IRM. Questions can be directed to Mr. Charles Fabian, ASC/ENSI, (937) 255-4002, or Mr. Earl Kessinger, ASC/FMCR, (937) 656-5473.

John L Hudson
JOHN L. HUDSON
Lieutenant General, USAF
Commander

"IRM … integrates the technical, schedule, and cost impacts of risk areas into a complete picture …."

Integrated Risk Assessment

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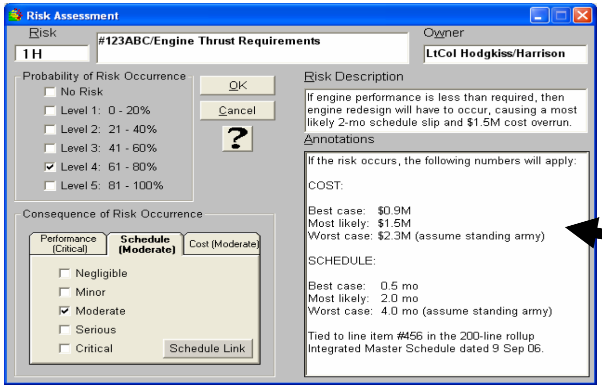
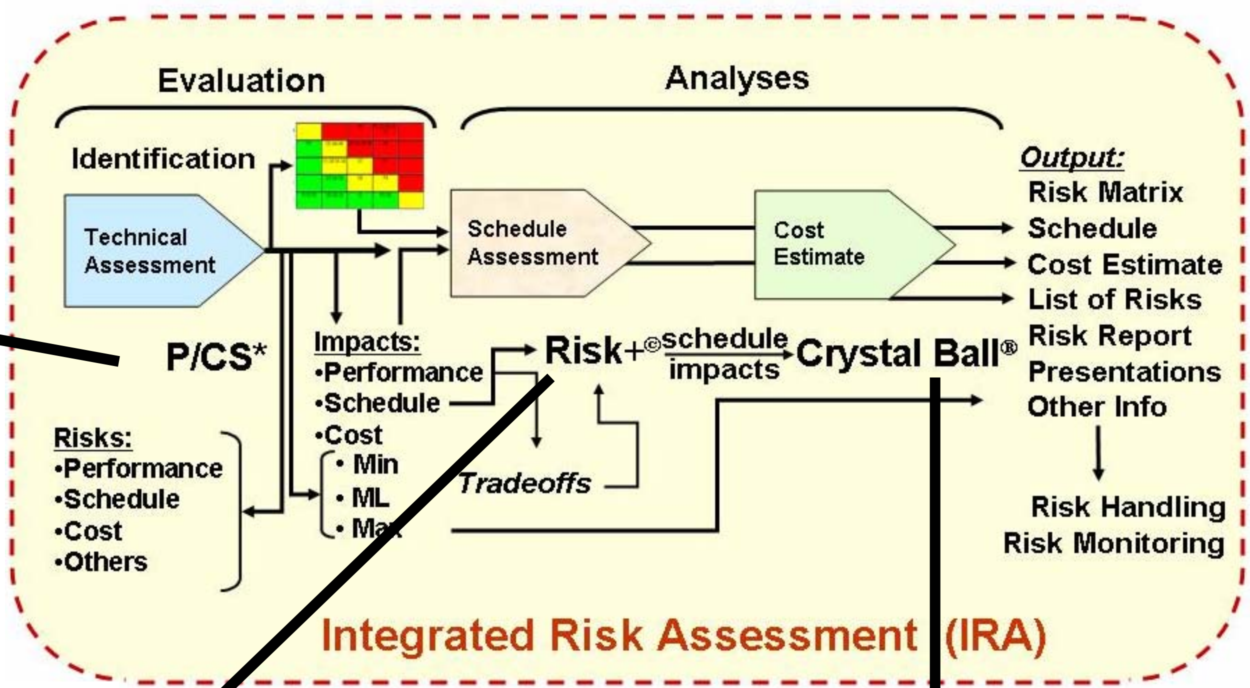
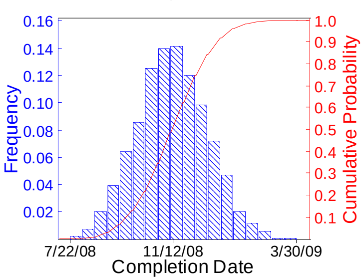


Updated compilation of (C/S/P) risks



Date: 8/31/2006 1:36:52 PM
Samples: 5000
Unique ID: 1
Name: ASIP Program

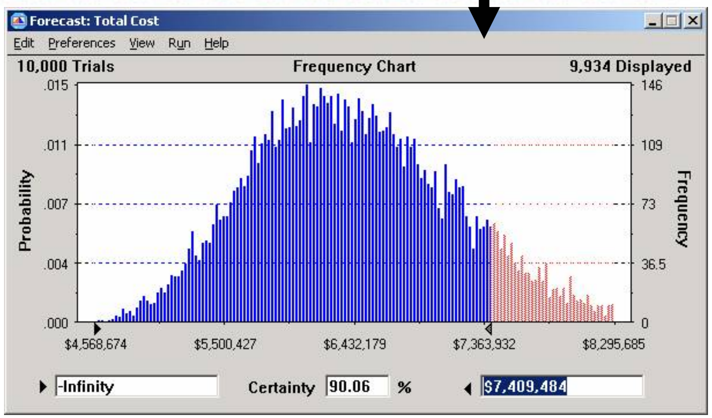
Completion Std Deviation: 27.55 days
95% Confidence Interval: 0.76 days
Each bar represents 10 days



Completion Probability Table

Prob	Date	Prob	Date
0.05	9/9/08	0.55	11/17/08
0.10	9/23/08	0.60	11/21/08
0.15	10/2/08	0.65	11/26/08
0.20	10/9/08	0.70	12/3/08
0.25	10/16/08	0.75	12/9/08
0.30	10/23/08	0.80	12/16/08
0.35	10/28/08	0.85	12/23/08
0.40	11/3/08	0.90	1/1/09
0.45	11/6/08	0.95	1/14/09
0.50	11/11/08	1.00	3/30/09

probability distribution - total program cost



probability distribution - program completion date

Risk Summary (IRA)

U.S. AIR FORCE

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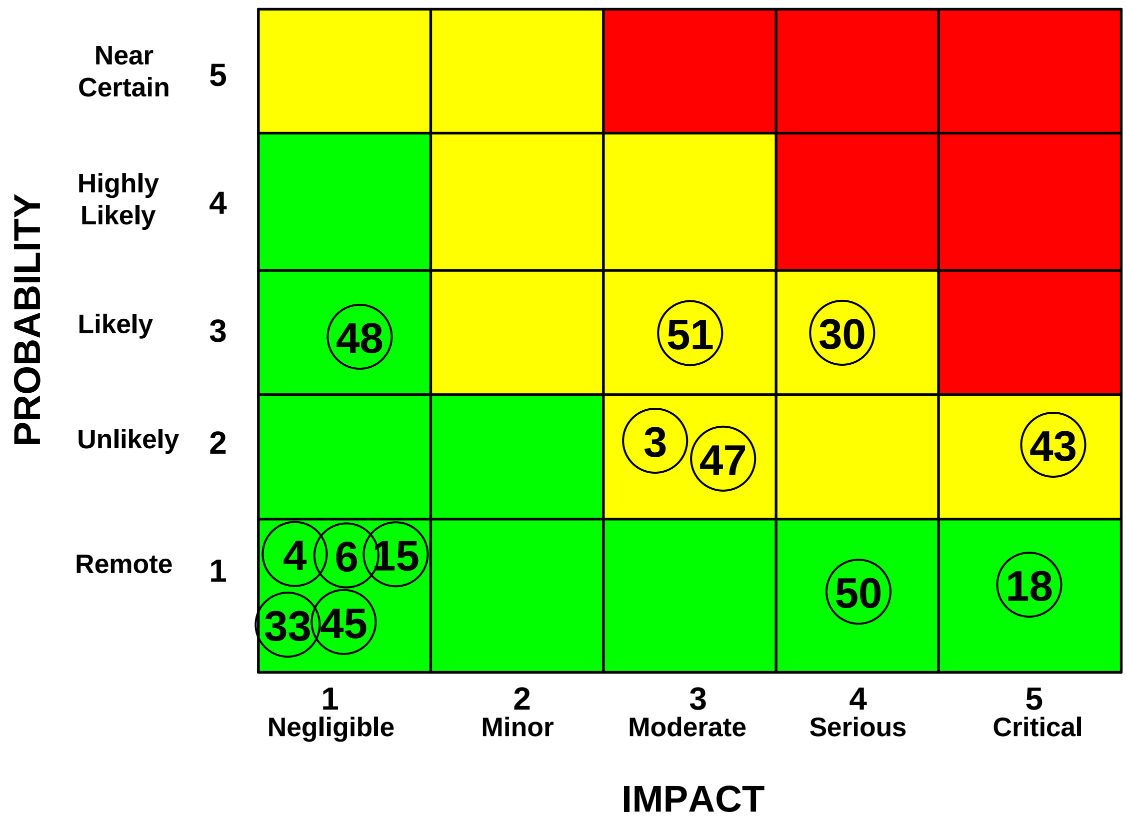

3. Sensor Qualification Testing
4. U-2 Accreditation
6. Site 2 Accreditation
15. U-2 Timing Source Stability
18. Edwards Connectivity to Site 2
30. GH SAR Antenna Positions
33. ASIP EMSEC Test on Flight Test/Production A/C
43. Certified DL Encryptor not Available for Fielding
45. FARSITE Support
47. Sensor/DCGS Interface Testing
48. GH Ku/Band 5 Corrective Action Effectiveness
50. GH Payload Weight
51. Flight Test Sortie Rate

2 risks have greatest potential to impact schedule:
#30 GH SAR Antenna Positions
#51 Flight Test Sortie Rate

ASIP SoS Risk Management

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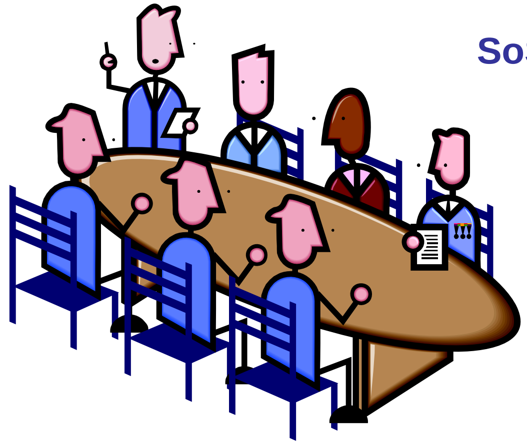
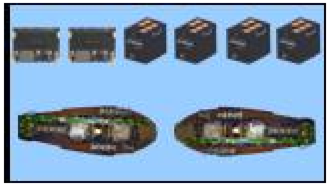


SoS Risk Review Board

Jeopardize SoS level performance or event

SoS Risks

Require Government or associate contractor effort



LOCKHEED MARTIN

Raytheon

L3 communications

NORTHROP GRUMMAN

ASIP Risk Management Process Model

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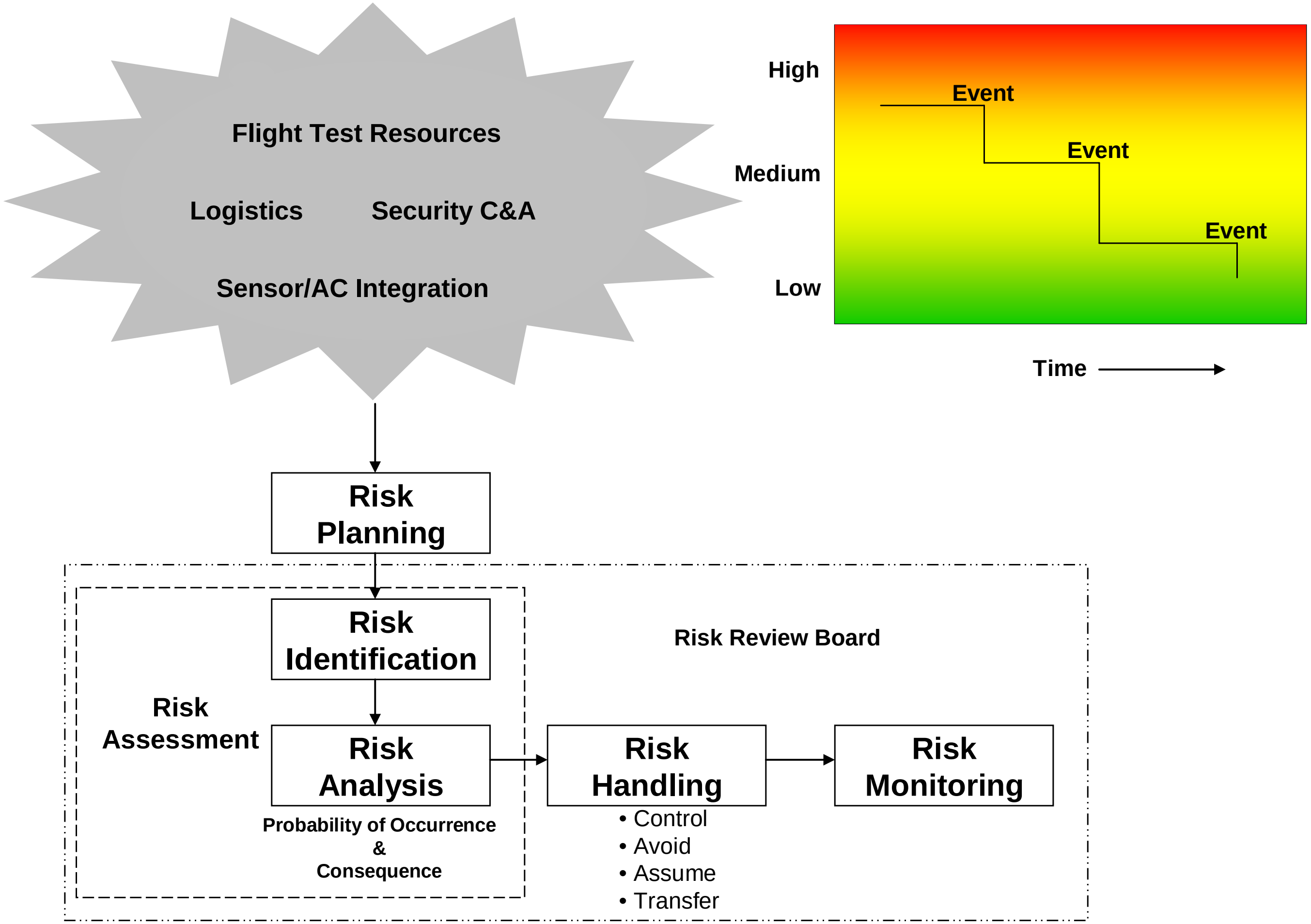

Best Practices

- **Conduct monthly risk review boards**
  - **PMs & CEs actively involved**
- **Include mitigation activities in IMS**
- **Brief status regularly to senior leaders**
- **Carefully describe risks**
  - **If (root cause), then (bad outcome)**
- **Address contractor & government risks**
- **Include step-downs in mitigation plans**

ASIP Results

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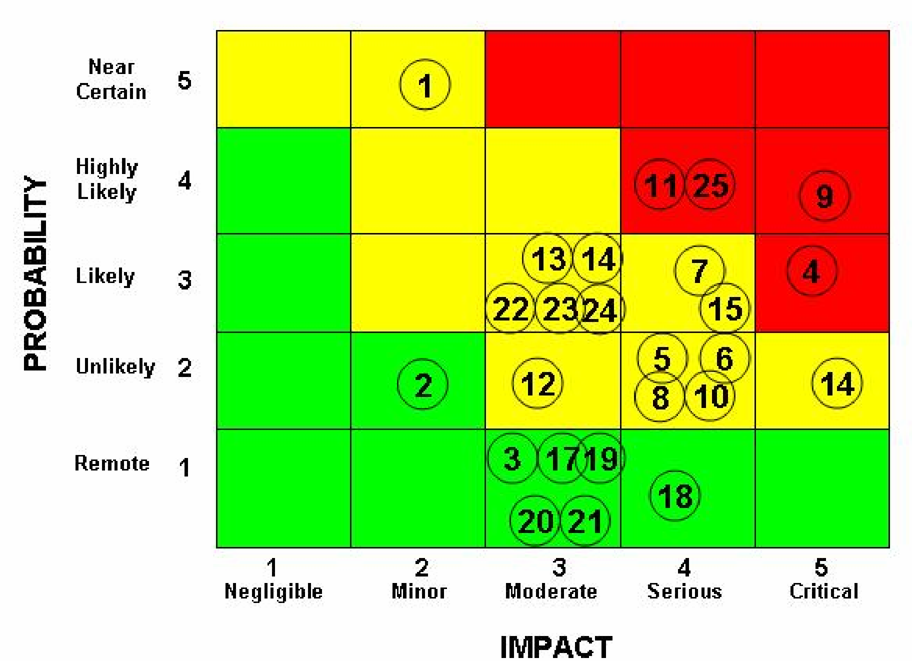
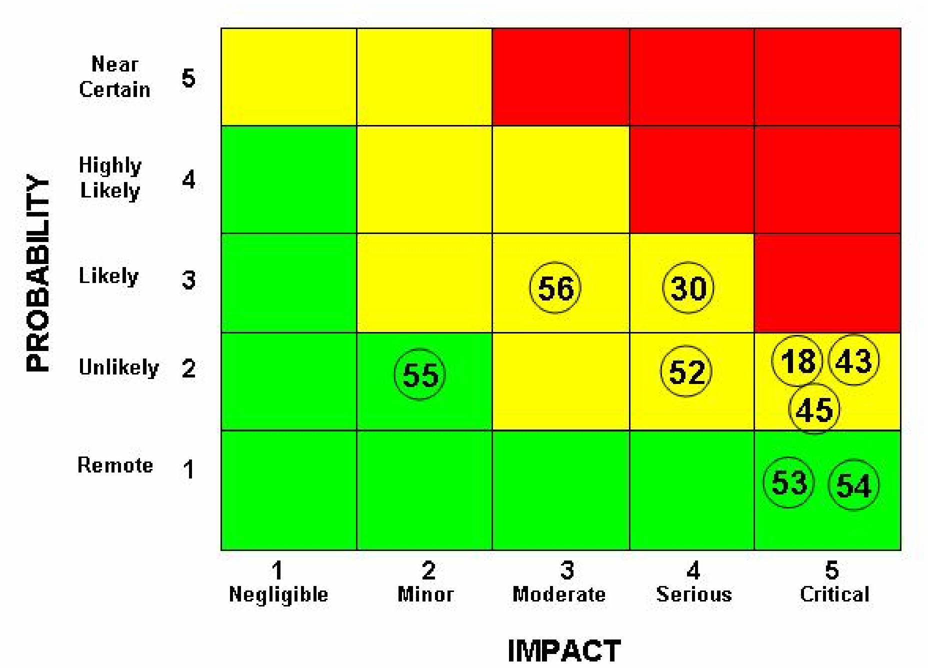


May 2005



Sep 2007

Accepted: Issues:	**#29 - GH ICD Temp Inconsistency with EAU Spec**
	#50 - GH Payload Weight
	#51 - light Test Sortie Rate

Risk Metrics

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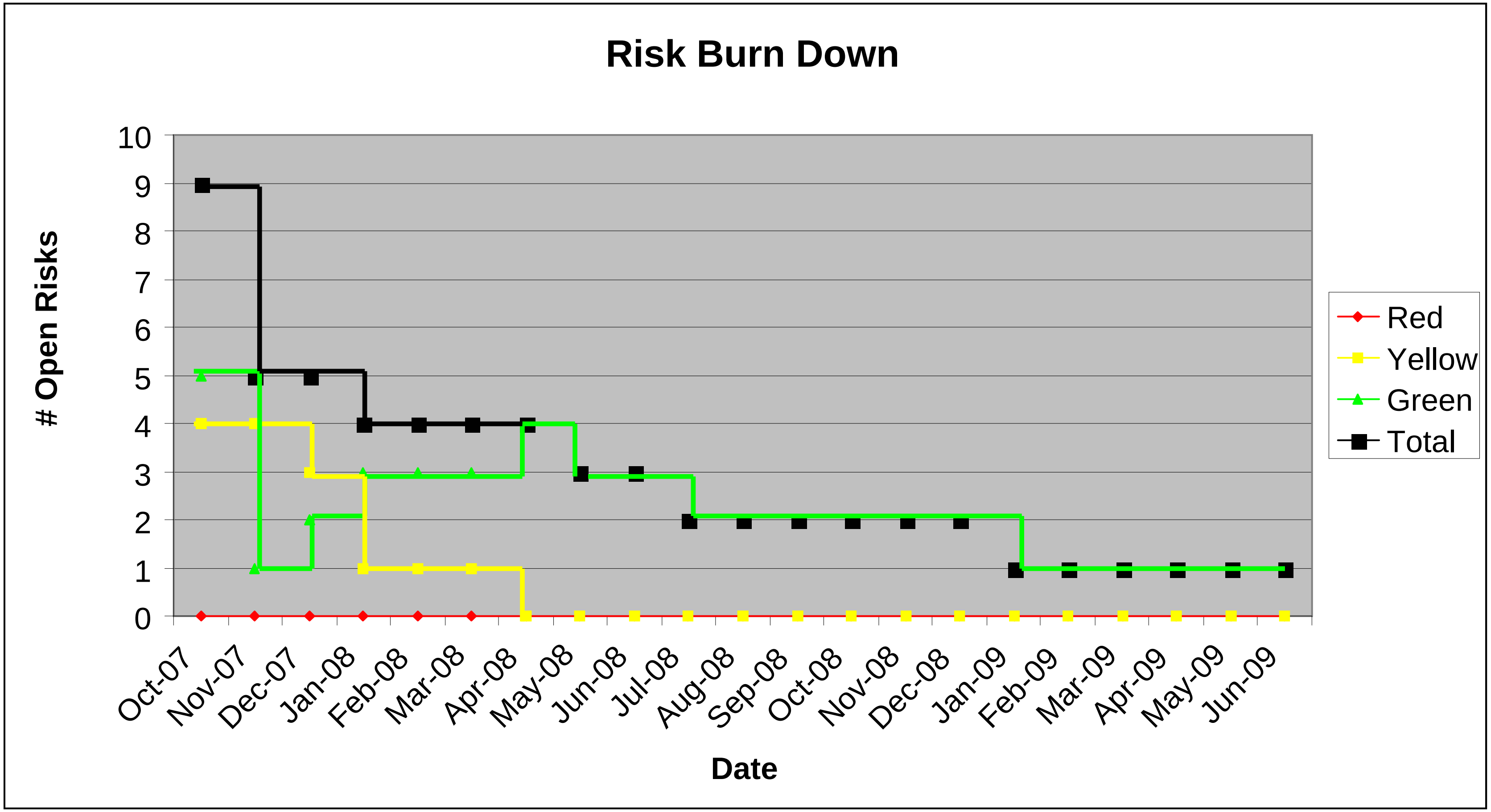


Take Aways

- **Risks are present in every program**
  - **Can't afford no/low risk programs**
  - **May be acceptable if provides opportunity**
- **Risk management is proactive**
  - **Determines where/when to use resources**
  - **Necessary to make acquisition programs executable**

"If you don't actively attack the risks, they will actively attack you."

~ Barry Boehm in Software Risk Management

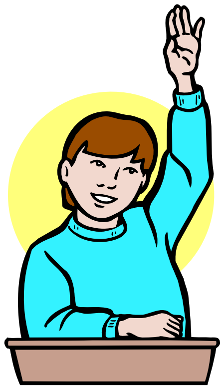
I cannot imagine any conditions which would cause a ship to founder.

Captain E. J. Smith, 1906

Questions/Comments

Dominant Air Power: Design For Tomorrow…Deliver Today

?



I n t e g r i t y - S e r v i c e - E x c e l l e n c e

"Do It Right, Do It Early; Do It Early, Do It Right"

Considerations for the Early Stages of Concept, System, and System-of-Systems Definition

NDIA 10th Annual
Systems Engineering Division Conference
San Diego, CA
24 October 2007

Jeff Loren
MTC Technologies, Inc. (SAF/AQRE)
703.588.7845
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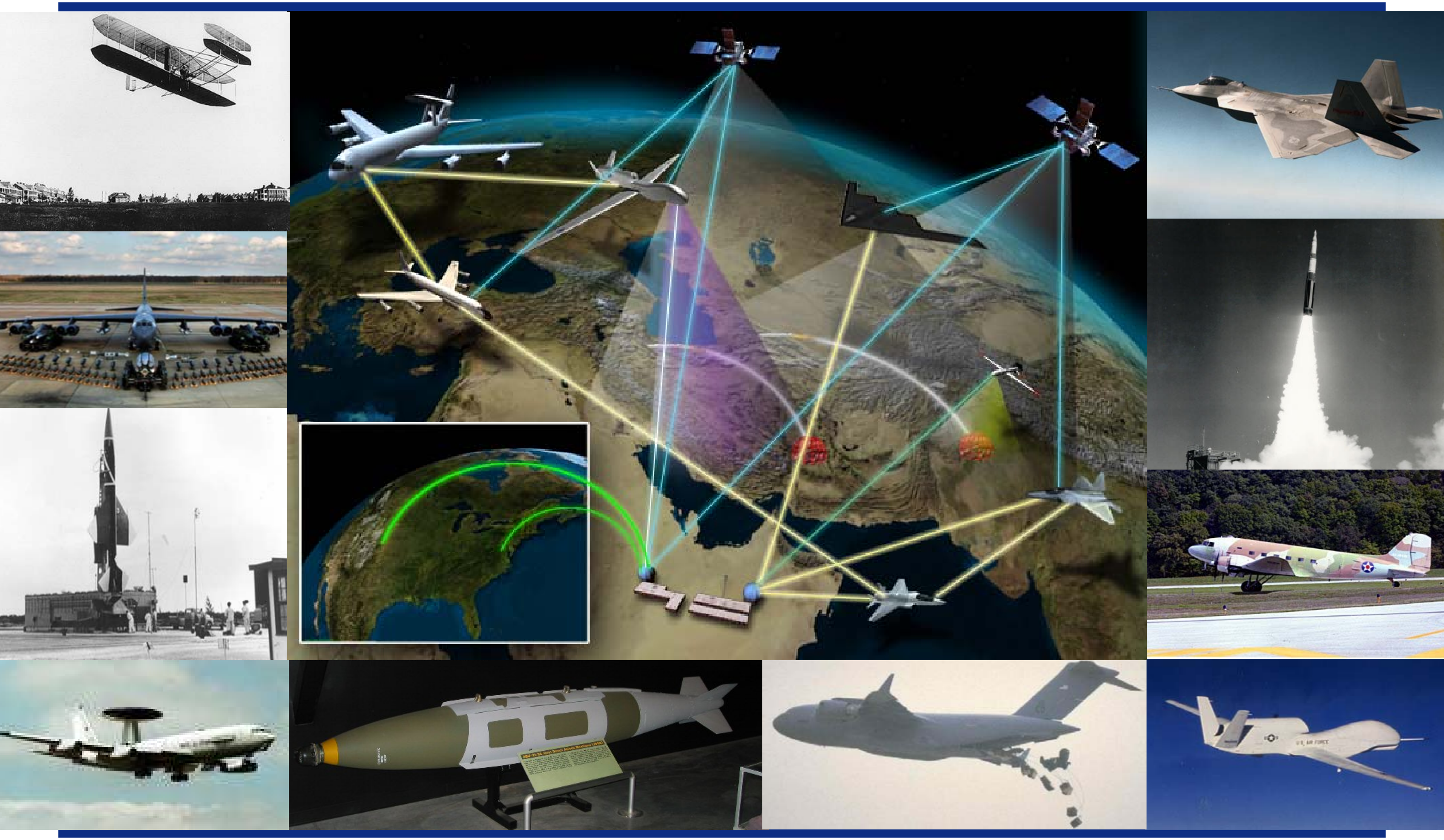
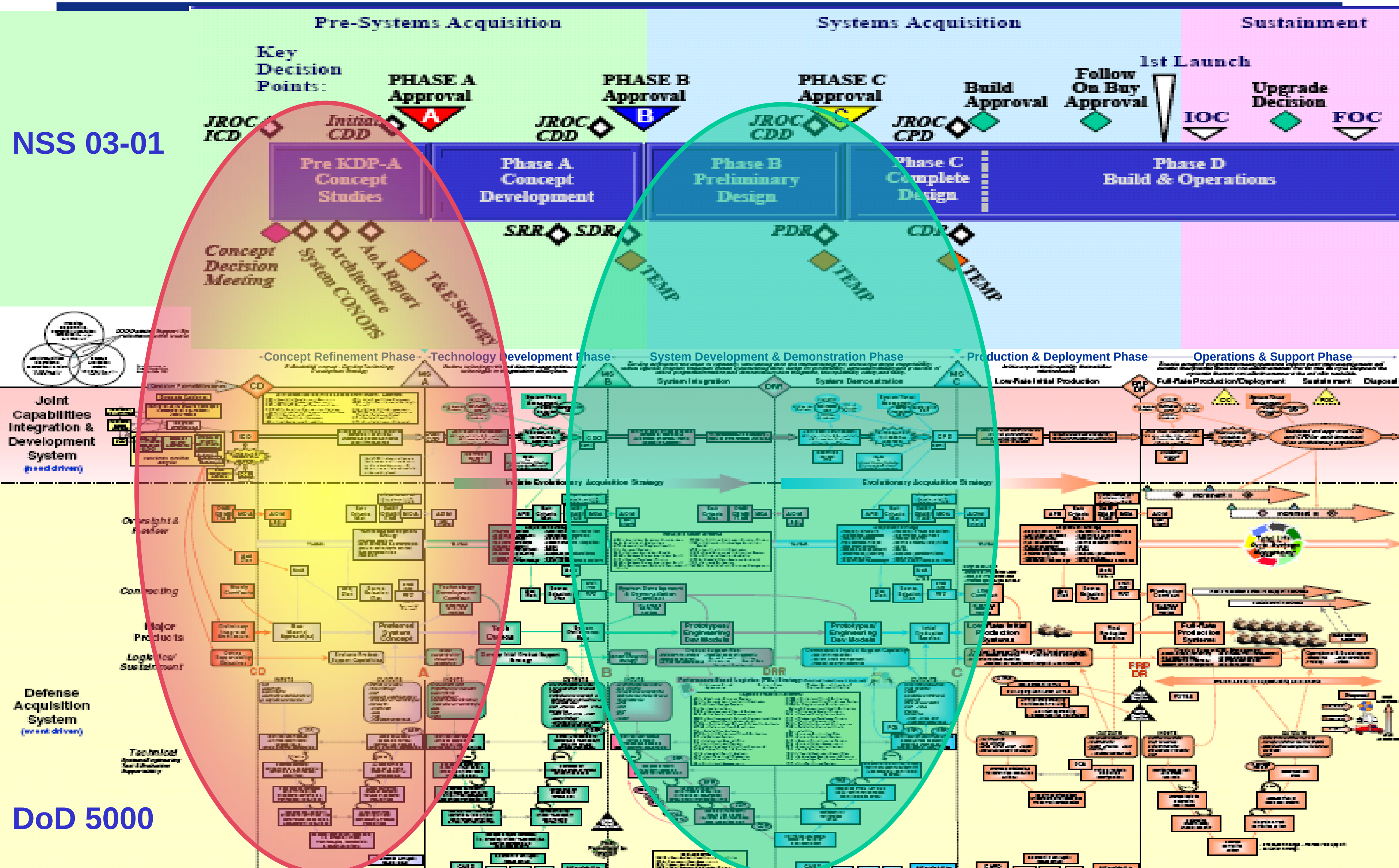
Historical Perspective



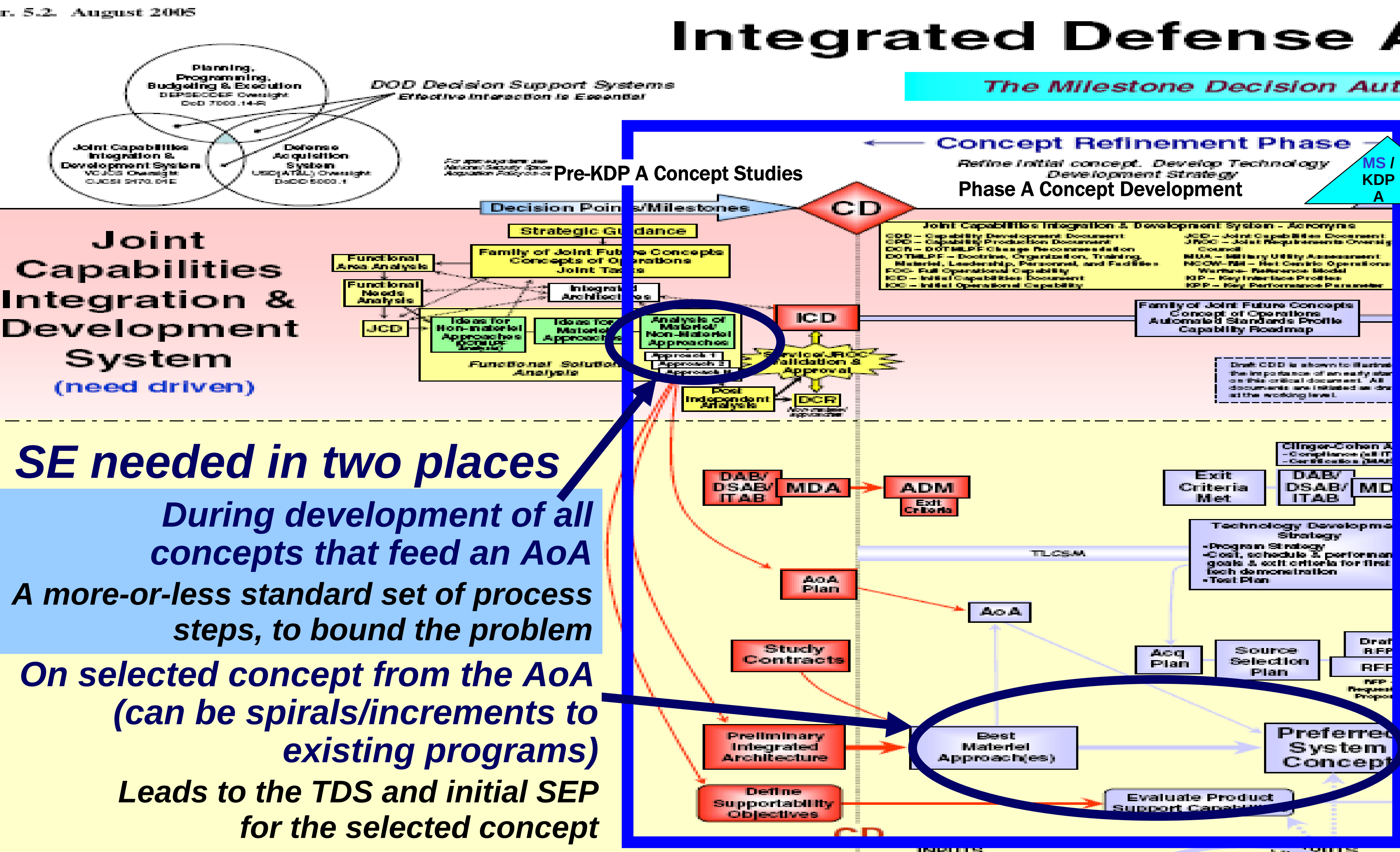
Pre-Acquisition SE
(“Pre-A Systems Thinking”)
Overview

- **Where It’s Required**
- **What It Is (and Is Not)**
- **Key Attributes**
  - **Universal**
  - **Collaborative**
  - **Not for the neophyte**
  - **Responsive but realistic**
  - **Smart choices**
- **Why It’s Important**
- **The Road Ahead …**

Acquisition Life Cycles
NSS 03-01 and DoD 5000



Pre-Acquisition “Systems Thinking”
Where It’s Required



SE needed in two places

- *During development of all concepts that feed an AoA*
  - *A more-or-less standard set of process steps, to bound the problem*
- *On selected concept from the AoA (can be spirals/increments to existing programs)*
  - *Leads to the TDS and initial SEP for the selected concept*

Pre-Acquisition "Systems Thinking"
Informing the Decision-Making Process

What it is:

- **Linkage between JCIDS and the AoA**
- **A disciplined process to:**
  - ***Scope capability needs***
  - ***Develop concepts***
  - **Do necessary *groundwork for a successful AoA***
- **Essentially a method to develop AoA entry criteria**
- **A means to identify candidate solutions and assess their TRLs**
- **Basis for Technology Development Strategy (TDS)**
  - **TDS should make up ~75% of content of SEP submitted at Milestone / Key Decision Point A for selected concept**

Pre-Acquisition "Systems Thinking"
Informing the Decision-Making Process

Alternate view:

- "Analysis of Problem" as precursor to formal AoA
  - Methodology that uses SE processes to translate capability statements into families of concept designs/approaches
    - Trade study process
    - Key ground rules / constraints
    - Decision criteria
    - Methodology for populating knowledge base
  - Describes how operational context (architectures, military utility, etc.) drives these translations

What it is *not*:

- **An actual requirement development effort under JCIDS**
- **An actual AoA**
- **"Gaming the system" in favor of a particular or pre-determined solution**

Attributes

- Universal
- Collaborative
- Not for the neophyte
- Responsive but realistic
- Smart choices

Universality

- **Applies to all domains, industries, product areas, research areas …**

- **One size (policy, process, procedure, prior idea …) seldom fits all**

Expanding the "V"

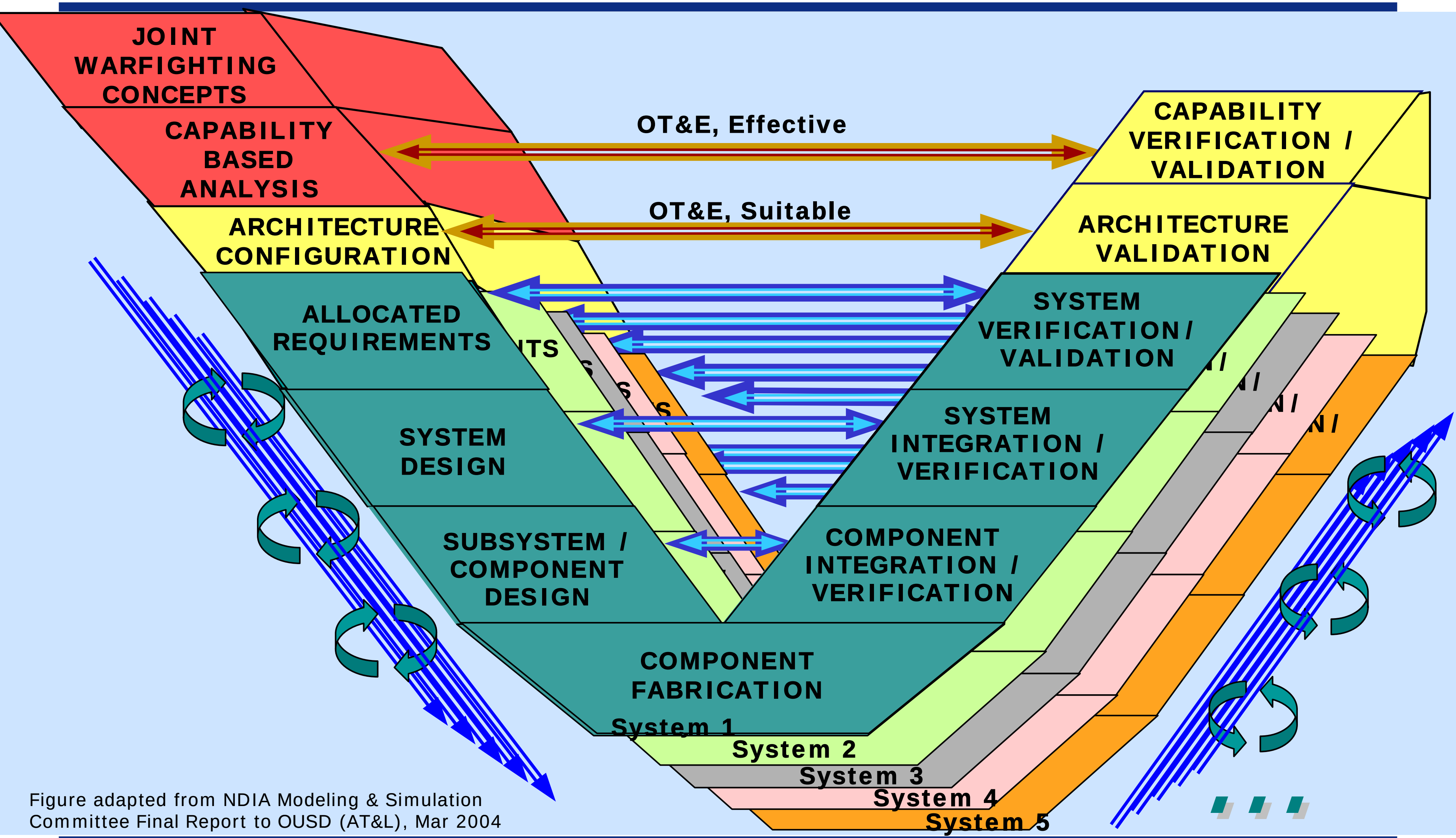


Figure adapted from NDIA Modeling & Simulation Committee Final Report to OUSD (AT&L), Mar 2004

Collaboration

- **Understand the realities of -- and constraints imposed by -- external factors and influences across government, industry, academia**

- **The human is an external factor, and always introduces uncertainties**

SE for SoS Challenges

- Unique management and governance issues
  - Assets acquired / operated under disparate systems and policies
  - Allocation of requirements to constituent systems
- Integration / Verification
  - Defining architectures to link systems and platforms
  - Resource constraints on physical testing drive extensive M&S
  - Experimentation as a development tool
  - Relatively *ad hoc* configurations in operational environment
  - Legacy system modifications / updates
    - Proprietary issues
    - Less-than-open subsystem and component designs
- Measurement
  - Difficult to quantify non-functional requirements
  - Mission-related quality attributes (interoperability, security, etc.) largely depend on architecture

Thinking

- **Know what you want,**
  and measure smartly …

  Accuracy $\neq$ Precision

- **Beware of becoming "DRIP"**

  Data-Rich, Information-Poor

DoD 5000 PHASE	CONCEPT DEVELOPMENT (R&D)		CONCEPT REFINEMENT / TECH DEVELOPMENT		SYSTEM DEVELOPMENT & DEMONSTRATION		PRODUCTION & DEPLOYMENT		OPERATIONS & SUPPORT	
ISO 15288 STAGE	??		??		??		??		??	
APPLICATION / INDICATOR	System	SoS/ Architecture/ Enterprise	System	SoS/ Architecture/ Enterprise	System	SoS/ Architecture/ Enterprise	System	SoS/ Architecture/ Enterprise	System	SoS/ Architecture/ Enterprise
REQUIREMENTS DEFINITION (growth, correctness/completeness)										
SYSTEM DEFINITION CHANGE RATE	0	0	1	2	3	3	3	2	1	3
REQUIREMENTS VALIDATION										
REQUIREMENTS VERIFICATION										
INTERFACE DEFINITION internal										
external										
REVIEW ACTION CLOSURES	0	1	2	2	3	2	3	2	1	1
APPROVALS internal										
external (customer)	0	1	1	1	3	3				
TECHNOLOGY MATURATION new	2	2	3	3	3	3				
old (obsolescence)					2	2				
RISK EXPOSURE	0	1	1	2	3	3	3	3	3	3
RISK HANDLING										
STAFFING / WORK EFFORT headcount										
work package completion					3	1	3	1	1	1
PROCESS COMPLIANCE	0	0	1	1	2	1	1	1	1	2
TECHNICAL MEASURES	1	1	2	2	3	3	3	3	2	3

Table entries (values are notional):
- 0 - not applicable
- 1 - low
- 2 - nominal
- 3 - high

Leading Indicators

Value by Life Cycle Phase

Candidate Metrics for the Concept Development Process

- Distribution of concepts in the development process pipeline
  - Number of items in each of the various stages of a concept's lifespan
- Concept relevance
  - How well a set of concepts addresses the cost / performance / schedule trade space for a specific shortfall
- Baseline concept schedule
  - Progress of efforts to develop relevant and mature concepts to meet a shortfall

Candidate Metrics for Development of a Concept

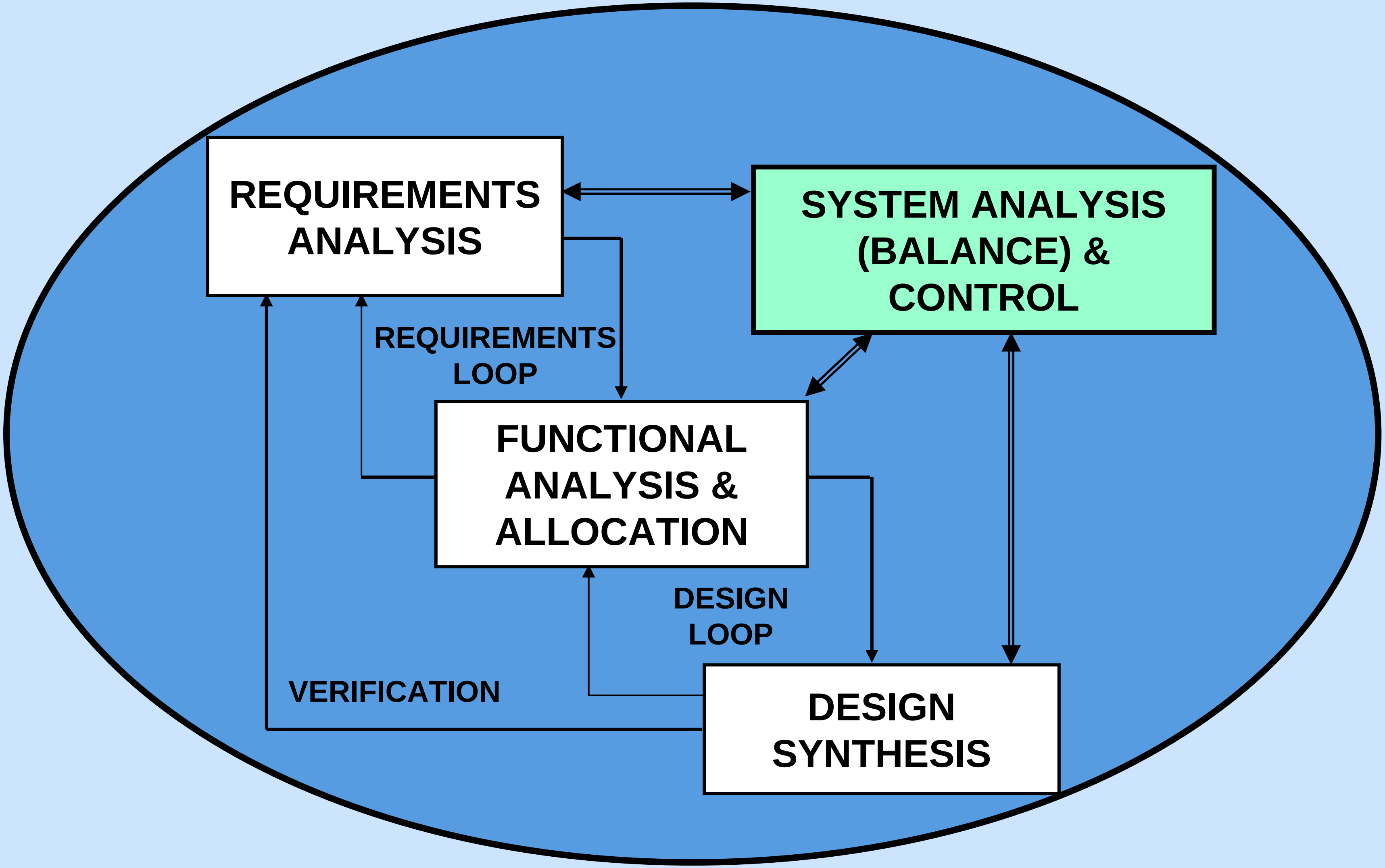
- Supporting analyses
  - Cost
  - Risk
  - Military Utility
  - Other
    - Technology suitability
    - Producibility
- Technical progress
  - Node analysis
  - System- and subsystem-level trades
  - Key reviews
    - Acquisition strategy
- Transition opportunities

Rational

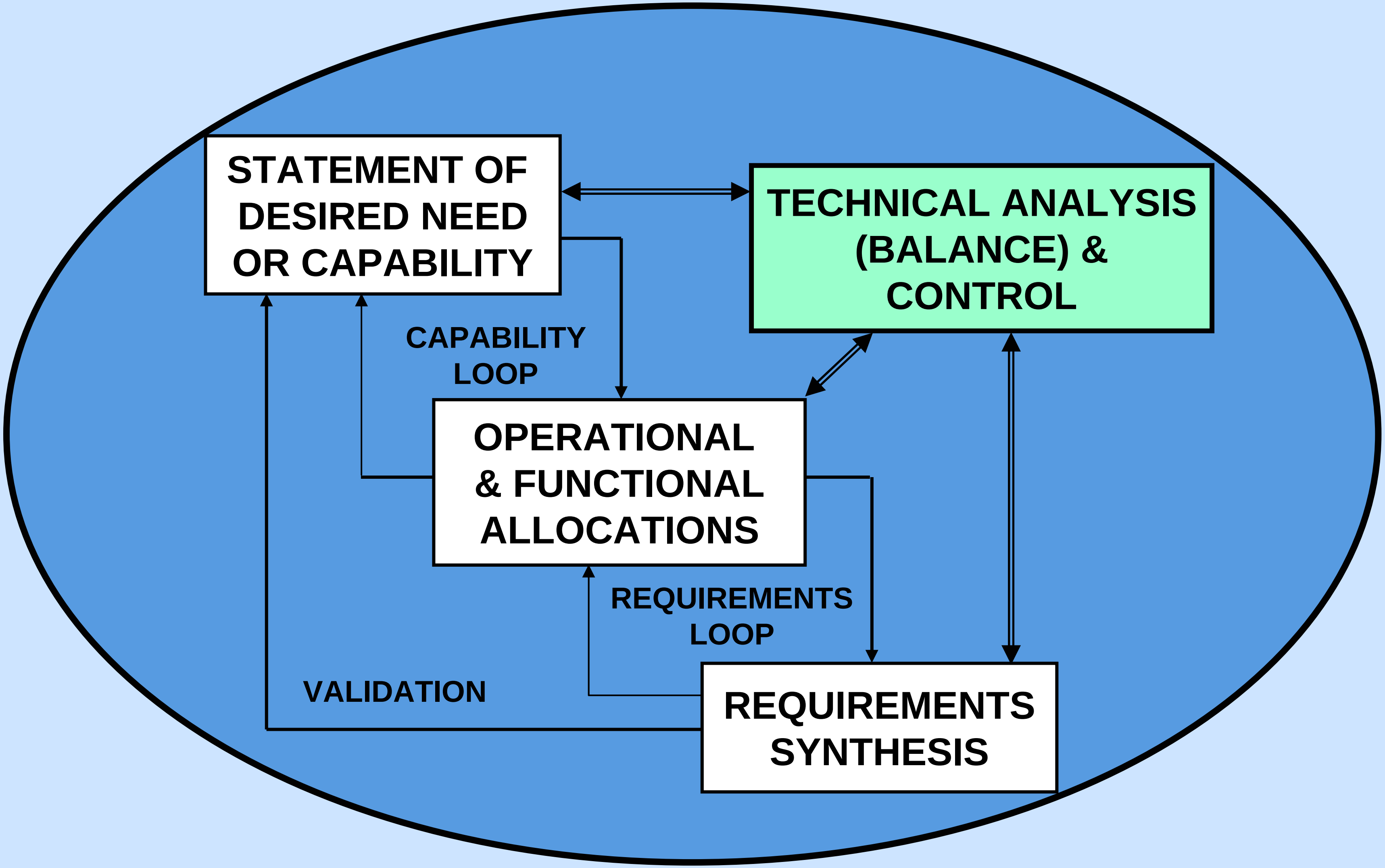
- Customers/users often press for immediate solutions over rigorous process

- "Then a miracle occurs" cannot be an acquisition or transition strategy

SE for a Product or System
Transforming Requirements to Design



"Systems Thinking" for a Capability
Transforming Needs to Requirements

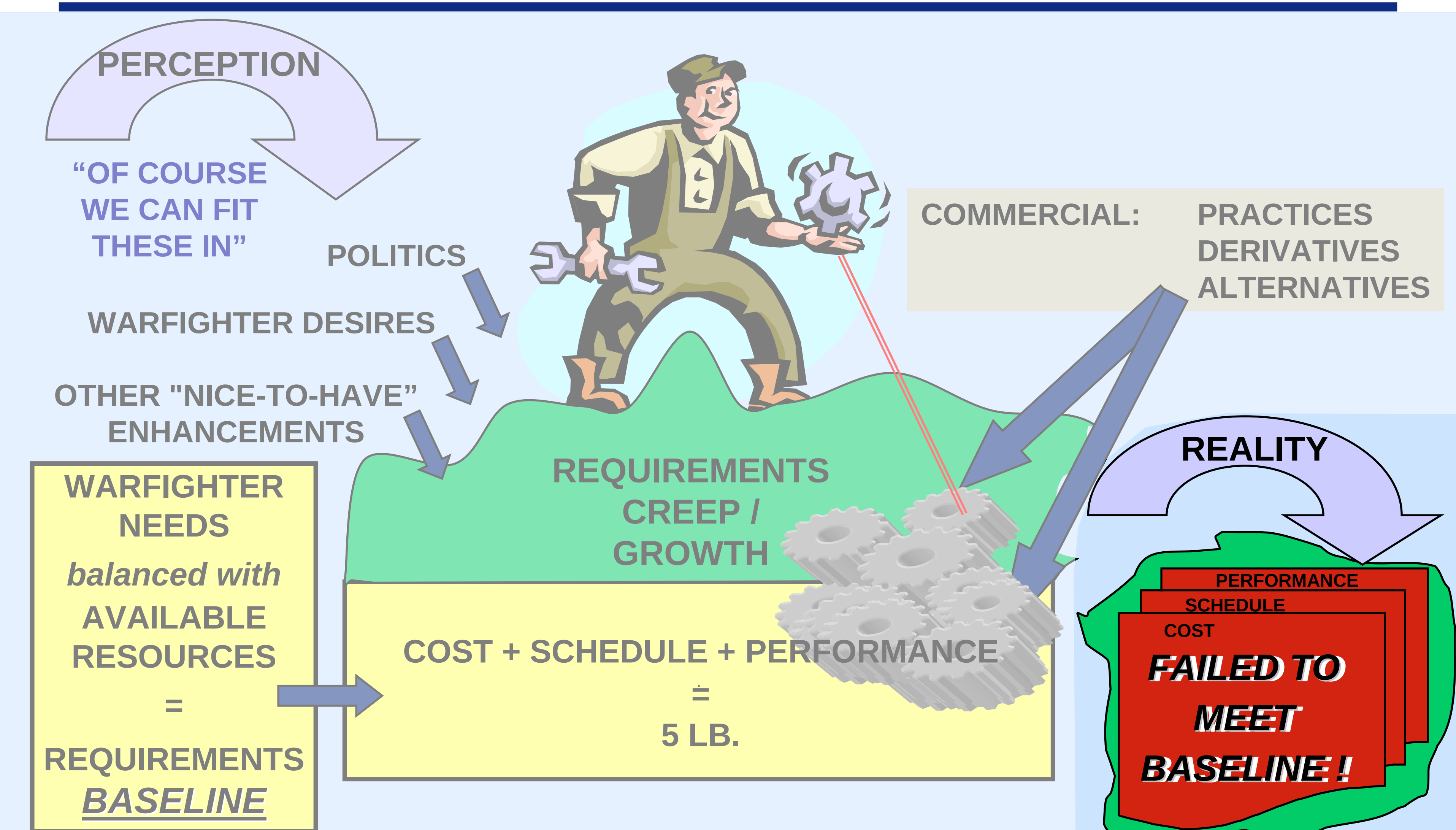


Decisive

- **Decomposition and allocation must focus on HW, SW, or human first; this decision is a huge driver in defining the rest of the solution trade space**

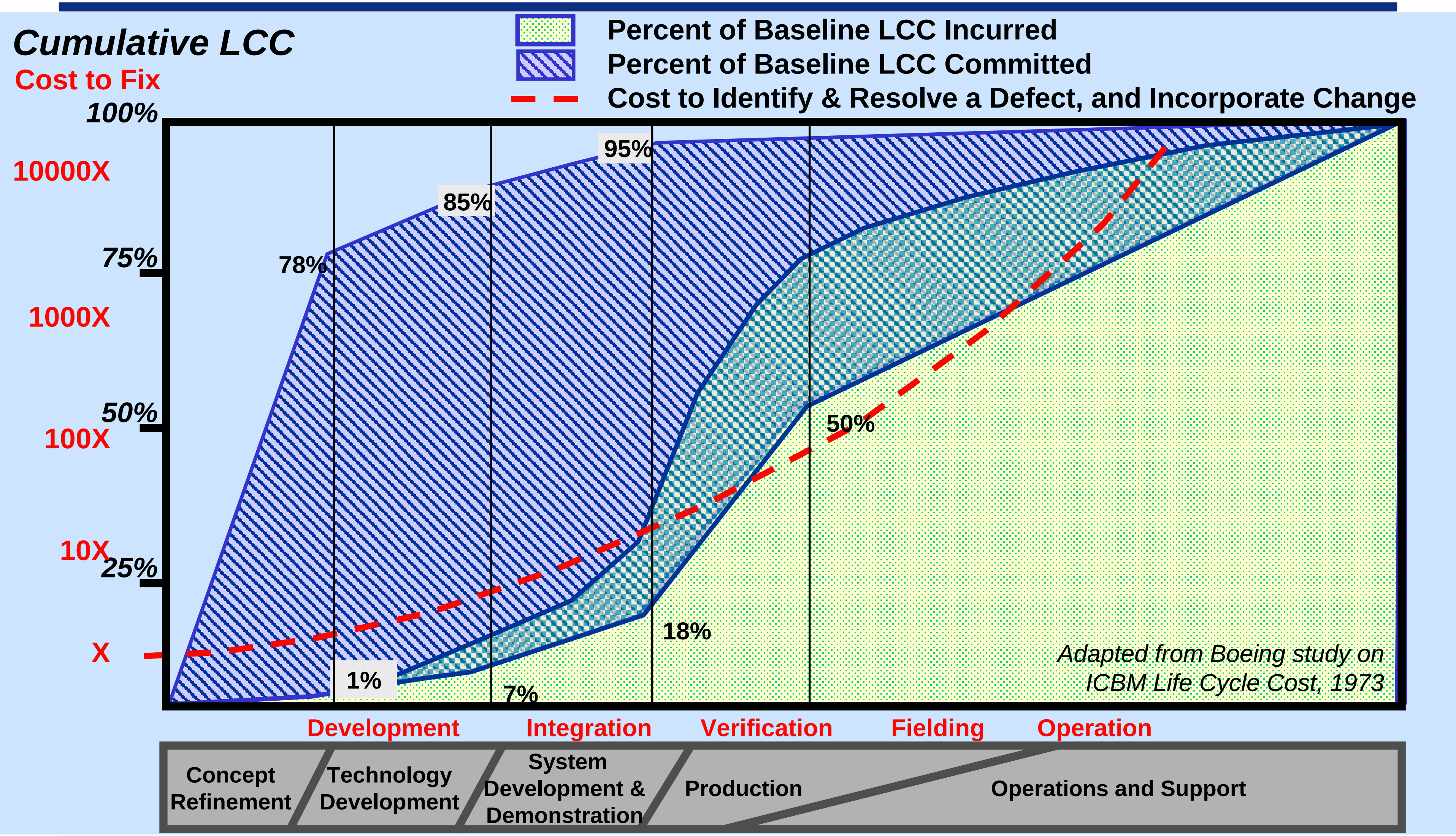
- **Do it right, do it early; do it early, do it right: Systems Engineering follows -- but must NOT replace -- Systems Thinking**

How We Try to Fit 10 Lb. of PROGRAM Into a 5 Lb. BASELINE



Why It's Important

Early Decisions Are Key Cost Drivers



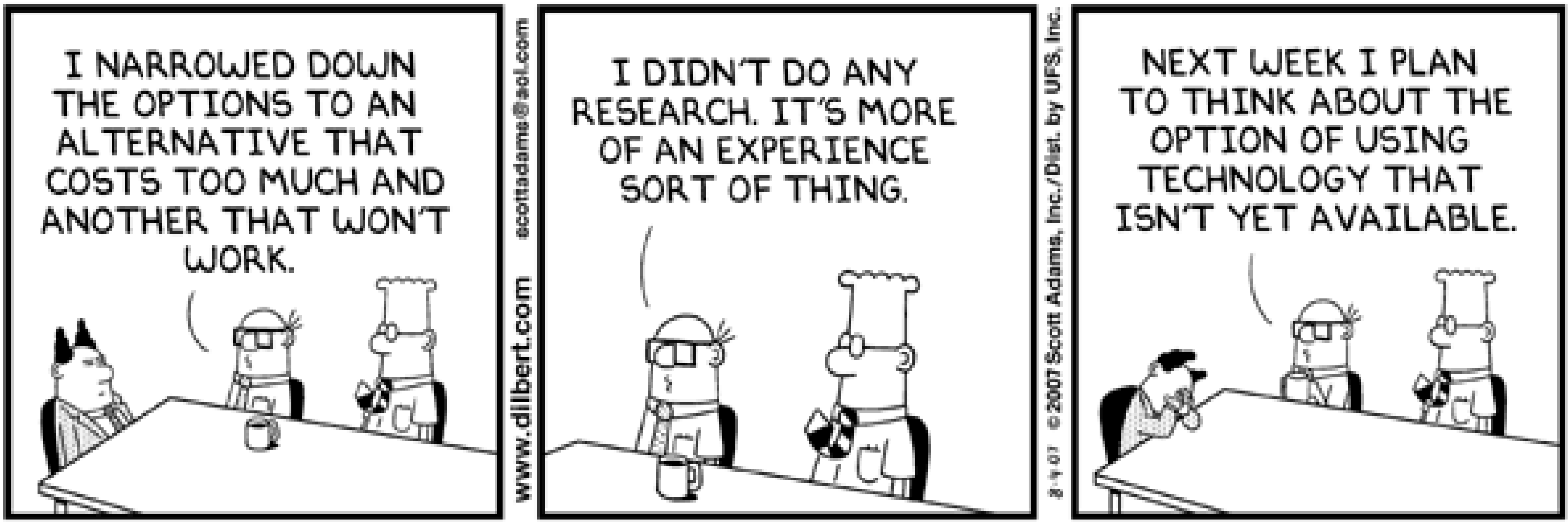
Top 10 Considerations for Applying Systems Thinking Early in the Life Cycle

- **Applies to all domains, industries, product areas, research areas …**
- **One size (policy, process, procedure, prior idea …) seldom fits all**
- **Understand the realities of -- and constraints imposed by -- external factors and influences across government, industry, academia**
- **The human is an external factor, and always introduces uncertainties**
- **Know what you want and measure smartly … Accuracy ≠ Precision**
- **Beware of becoming "DRIP" -- Data-Rich, Information-Poor**
- **Customers often press for immediate solutions over rigorous process**
- **"Then a miracle occurs" cannot be an acquisition or transition strategy**
- **Decomposition and allocation can focus on either hw or sw first; this decision is a huge driver in defining the rest of the solution trade space**
- **Do it right, do it early; do it early, do it right: Systems Engineering must follow -- but must NOT replace -- Systems Thinking**

ULTIMATE RESULTS

- **Better technical planning, better integrated**
- **More confidence in programs entering acquisition**

How NOT to do Concept Development



BACKUPS

Status of Current AF Efforts

- **SMC pilot ongoing**
  - **Three drafts of process guide completed**
  - **Tailored Space Situational Awareness capability need statement; conducted exploratory trades and initial architecting**
  - **Currently in design phase for three concepts (one ground-based, two space-based); cost & Military Utility analyses ECD 30 Oct**
  - **Initial "Concept Engineering Plan" (ConEP) completed for each**
- **Proposing policy language to insert AF Chief Engineer review of concept pedigrees as AoA "entry criteria"**
  - **NOT an in-depth technical review**
  - **Provides avenue to weed out "back-of-the-napkin" concepts early**
- **ASC process guide in work; AAC & ESC pilots start CY08**

FUTURE STATE

- **Rigorous yet adaptable concept development processes across AF**
- **More robust concepts going into AoAs**

Pre-Acquisition "Systems Thinking"
Boundary Conditions

Pre-Acquisition SE efforts, like those throughout the rest of the life cycle, are essentially an "integrating function"

- **Pre-A SE mainly occurs in two domains, each with set boundaries**
  - **The first domain spans the period from JCIDS initiation of a need to AoA entrance:**

$$\int_{\text{JCIDS}}^{\text{AoA Entrance}} F_1(SE)\,dSE$$

  - **The second domain continues the SE functions after the AoA until formal program handoff:**

$$\int_{\text{AoA Exit}}^{\text{Program Initiation}} F_2(SE)\,dSE$$

- **The SE functions in both domains are fundamentally similar, but there are attributes unique to each**

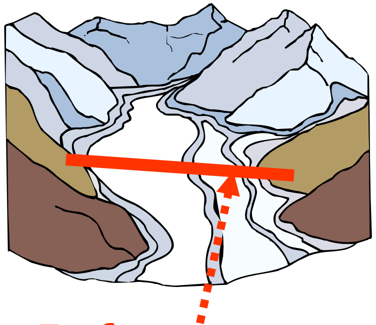
Pre-Acquisition "Systems Thinking" Example

Capability need: "Get people and equipment across a body of water"

- First pass asks key questions:
  - What does "water" mean? (Solution sets will be very different for Piscataway Creek, the Potomac River, and the Pacific Ocean.)
  - Are there any obvious constraints? (Sensitivity to water exposure? Time-in-transit limitations?)
- Initial analysis should yield various methods, and a cost / risk summary for each
  - Airlift
  - Bridge
  - Catapult (unsuitable for people)
  - Drive across (depends on depth, current, etc.)
  - Drive around (depends on total distance, thus time)
  - Ferry
  - Helicopter
  - Tunnel
- Analysts should also be able to quickly rule out candidates that don't meet constraints

Pre-Acquisition "Systems Thinking" Example 2

- Parametric trades within a method (bridge, tunnel, etc.) consider how relevant factors (depth, width, current, etc.) affect a baseline candidate solution
  - "A mile upstream the channel is narrower. The shorter span means ~30% less material cost, but road access and construction staging are difficult."
  - "A mile downstream the current is slower. The longer span means ~20% more material cost, but you can complete construction earlier."



- Once the AoA looks at families of candidates and concludes that a bridge is the best solution, a similar process is employed to determine the optimum type (cantilever, suspension, pontoon, single- or two-span draw, etc.)
- Pre-AoA measures are high-level programmatic / operational parameters (cost, schedule, vehicle capacity, etc.)
- Post-AoA measures have a more traditional design and execution focus (EVM, weight, material durability, etc.)

Focus Areas for SE Planning
Based on OSD SEP Preparation Guide

- **Program Requirements**
  - Capabilities, CONOPS, KPPs
  - Statutory/regulatory
  - Specified/derived performance
  - Certifications
  - Design considerations
- **Technical Staffing/Organization**
  - Technical authority
  - Chief/Lead Systems Engineer
  - IPT coordination
  - IPT organization
  - Organizational depth
- **Systems Engineering Process**
  - Technical processes
  - Technical management processes
  - Process improvements
  - Key tools and resources
  - Trade studies
  - Linkage to contractor SE effort
- **Technical Baseline Management**
  - Responsibilities
  - Definition of baselines
  - Requirements traceability
  - Specification tree and WBS link
  - Technology maturity and risk
- **Technical Review Planning**
  - Event-driven reviews
  - Management of reviews
  - Technical authority chair
  - Key stakeholder participation
  - Peer participation
- **Integration with Overall Management of the Program**
  - Linkage with other program plans
  - Program manager's role in tech. reviews
  - Risk management integration
  - Test and logistics integration
  - Contracting considerations

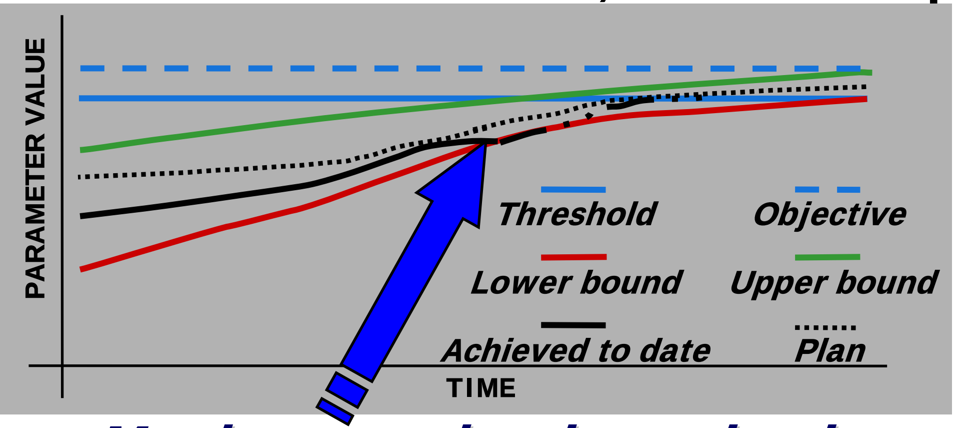
Highlight – greatest applicability to Pre-A efforts

Top Considerations for Applying Early SE to SoS

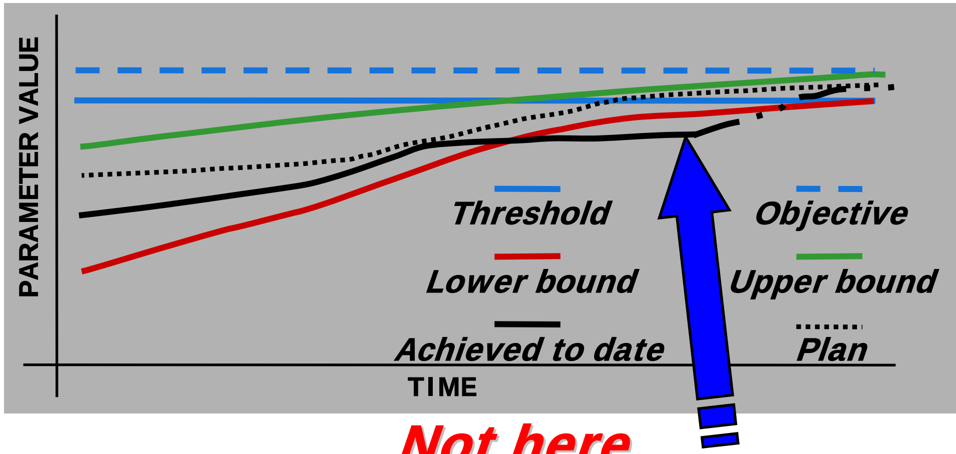
- **An end product that is usable as an individual entity (e.g., by s/n) is generally at the top level of the system architecture. An end product or capability that incorporates or requires multiple entities, many or all of which have human interfaces, is more of an SoS.**
- **The whole is not necessarily equal to the sum of the parts. What distinguishes a system of systems from a discrete system is that the behavior of the whole cannot be predicted from the aggregate of the constituent elements or subsystems. The existence of multiple human interactions / interfaces is a huge part of this.**
- **Integration and verification plans and resources must be in place early. This includes models and simulations, experimentation venues, and integration labs, as well as the physical assets to be tested. However, when analyzing test data, it is essential to remember that if enough is good, more is not necessarily better.**

Focus Areas for Technical Execution

- Representative parameters related to Technical Performance Measures (TPM)
  - Hardware – weight, speed, power, cooling, cross-section, bandwidth
  - Software – throughput, lines of code
  - Verification – test asset deliveries, test points completed with valid data
  - Logistics – reliability, maintainability
- Integration – physical and information interface definitions; verification plans
- Earned Value Management System (EVMS) data
  - Cost variances
  - Schedule variances
- Program execution
  - Staffing
  - Subcontracting
  - Specification approvals
  - Closure of review actions



Monitor trend; take action here
Plan is probably achievable



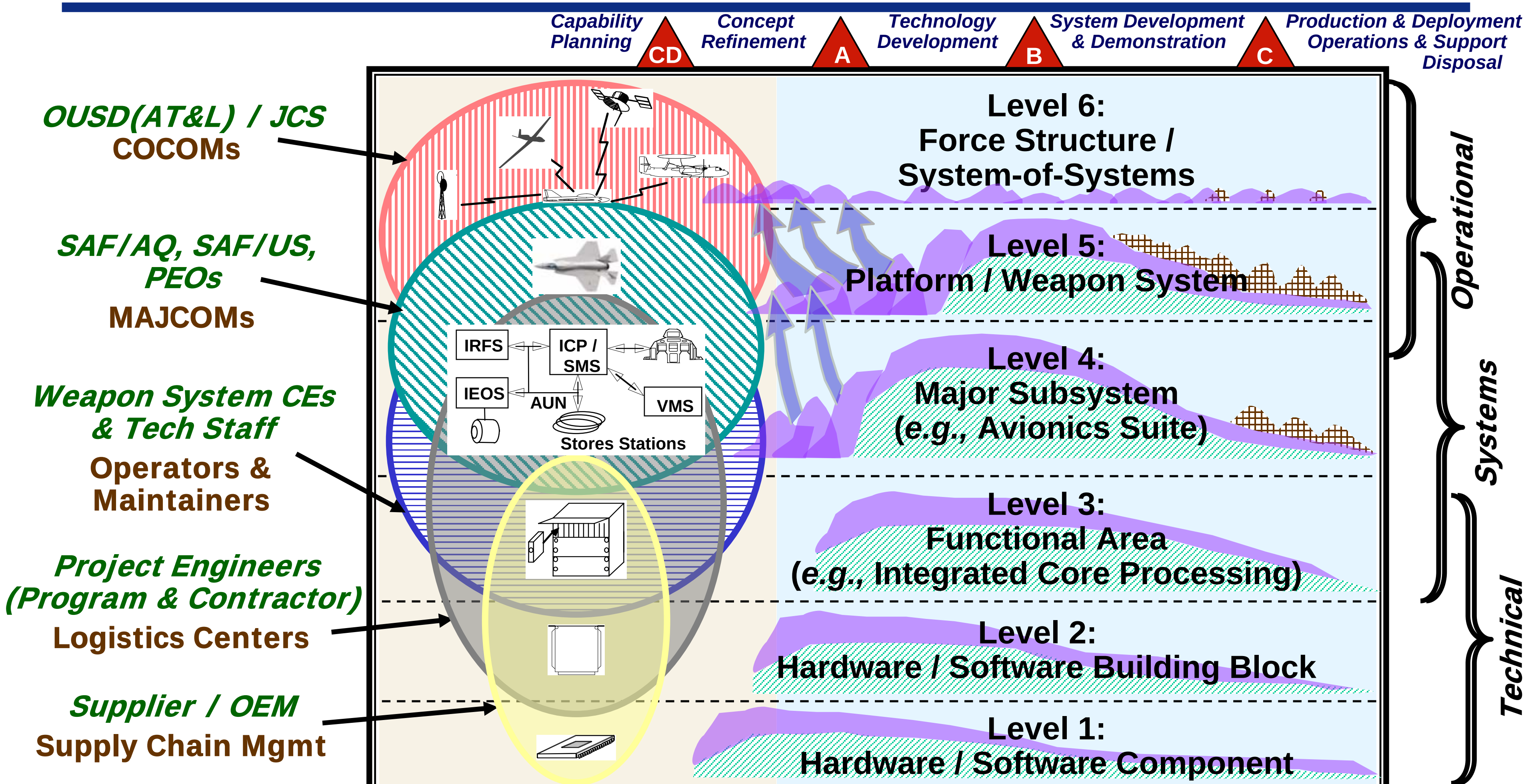
Not here
Overly optimistic "get-well" plan

Emerging Focus Areas

- Technical
  - SE for SoS / Architecting
  - Manufacturing Readiness
  - Human Systems Integration
  - Specifications and Standards
- Governance & Oversight
  - MDA Certification
  - System & Software Assurance (Security & Program Protection)
- Multi-Faceted
  - Enterprise-level SE
  - Industrial Base

SE Perspectives

Acquisition, Operations, Integration, Architecture



Views of the "universe"
Acquisition **Operational**

Test & integration focus (notional)
DT&E M&S / Experimentation OT&E

Architecture views
(spans are not authoritative)

Joint Mission Environment Test Capability (JMETC)

Briefing for the Tenth Annual Systems Engineering Conference

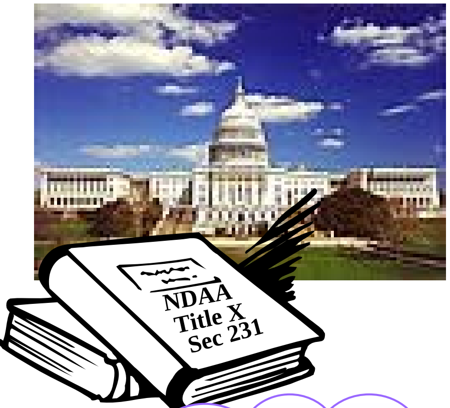
Mr. Richard Lockhart
Deputy Director,
Test Resource Management Center

October 24, 2007

TRMC Functions

- **DoD Field Activity**
- **Direct Report to USD(AT&L)**

★★★ **SES Director**



Biennial 10-Year Strategic Planning

Annual T&E Budget Certification
(Military Departments and DoD Agencies)

MRTFB Policy Oversight

Administer T&E Investment Programs
(CTEIP, T&E/S&T, JMETC)

Oversee T&E Budgets and Infrastructure
(MRTFB and other test facilities)

T&E Workforce

Sec. 231, FY 2003 National Defense Authorization Act
DoD Directive 5105.71, March 8, 2004

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TRMC Organization

Director
Dr. John B. Foulkes

Principal Deputy
Richard L. Lockhart

Front Office Group
(Chief Financial Officer, Sr Military Asst, Program Support, Executive Support)

Deputy Director
Test Resources
Vacant

Deputy Director
Joint Investment Programs & Policy
Richard L. Lockhart

- **Policy**
  Phyllis Ferguson
- **CTEIP**
  Derrick Hinton
- **JMETC**
  Chip Ferguson
- **T&E/S&T Program**
  George Rumford

Deputy Director
Test Infrastructure
Fred Myers

Deputy Director
Strategic Planning
Vacant

We are the stewards of the T&E Infrastructure

Outline

- ***Background***
- ***Program Overview***
- ***FY07 Accomplishments***
- ***FY08 Plan***

BACKGROUND

Testing in a Joint Environment Background

- **March 2004** – SPG: "Joint Testing in Force Transformation"
  - Policy – *Developing and fielding joint force capabilities requires adequate, realistic test and evaluation in a joint operational context*
  - Direction – *DoD will provide new testing capabilities and institutionalize the evaluation of joint system effectiveness*
  - Action – DOT&E lead development of a Roadmap to define changes *to ensure that T&E is conducted in a joint environment and facilitates the fielding of joint capabilities*

- **November 2004** – DEPSECDEF approved Roadmap, validated SPG
  - Roadmap identified actions to implement Testing in a Joint Environment, including
    - Strengthen and enforce DoD policy (DoDD 5000, CJCSI 3170, JCIDS) to elevate Joint testing requirements in DoD acquisition
    - Develop Joint testing processes and methodology
    - **Establish a corporate approach to Joint distributed testing capabilities**

> *"…a persistent, robust modern networking infrastructure for systems engineering, DT&E, and OT&E…must be developed that connects distributed live, virtual, constructive (LVC) resources"*

Testing in a Joint Environment Roadmap, dated 12 Nov 2004

Testing in a Joint Environment Background - continued

- **December 2005 PB 07 PDM**
  - Approved Joint Mission Environment Test Capability (JMETC) program to provide:
    - A corporate approach to joint distributed testing capabilities
  - Established PE under AT&L / TRMC for execution

- **October 2006**
  - JMETC Program Management Office established in Crystal City, VA

JMETC IS ONE YEAR OLD

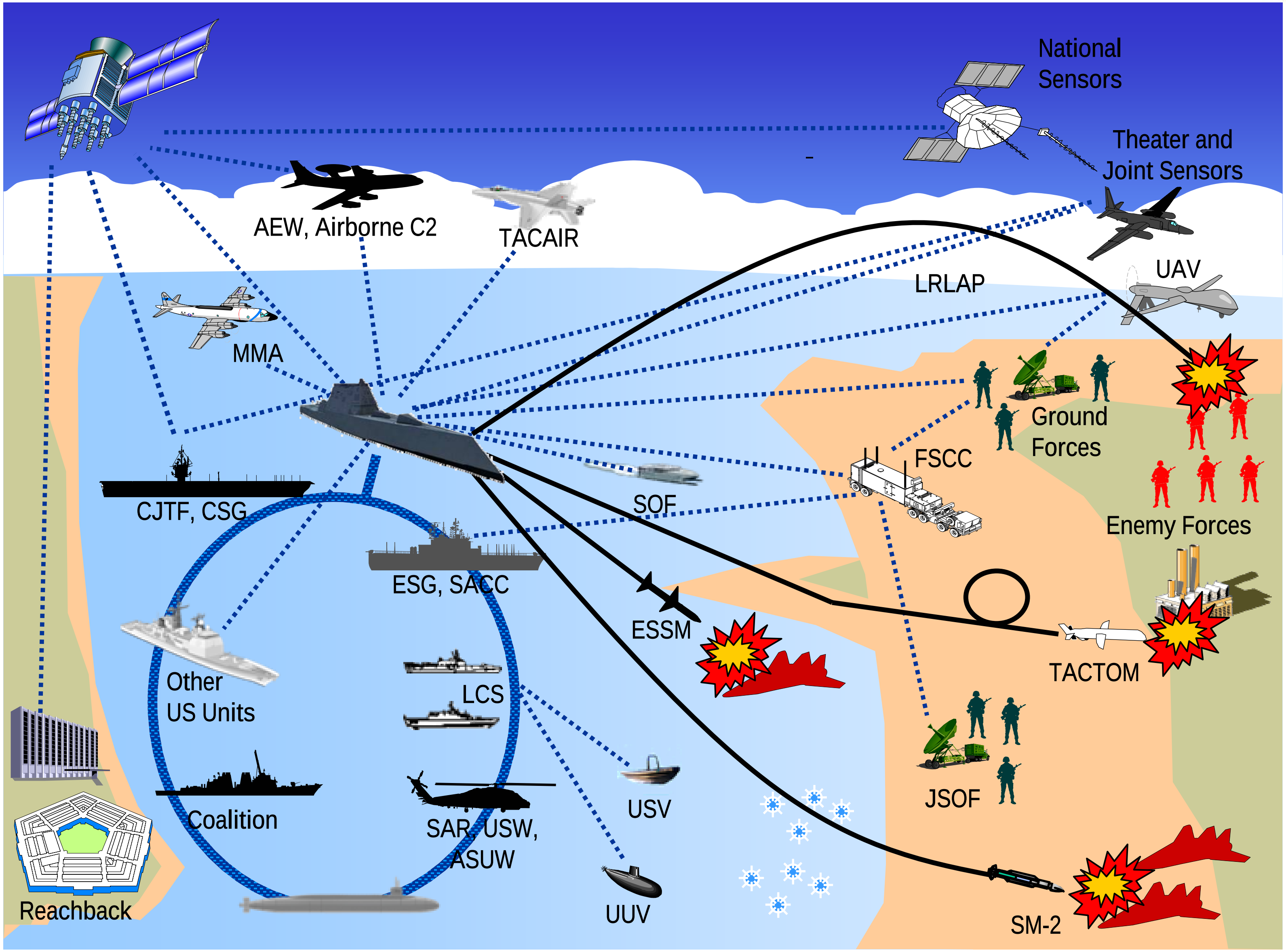
Interoperability / Net-Ready KPP Testing Requirement

> *"It is expected any resultant materiel solution will be verified through testing conducted in the expected joint operational environment to demonstrate joint interoperability and, when appropriate, net-readiness"*

CJCSI 3170.01F, dated 1 May 2007

- DoD Policy requires Joint interoperability and net-readiness testing during acquisition
- Interoperability and Net-Ready KPP testing requires testing interactions of multiple systems at the same time
  - Systems or their representations are not all co-located
  - Need to test early and throughout system development process
- Transition to the GIG to realize Net-Centric Warfare will increase the requirement for interoperability and, thus, increase the need for distributed testing

Notional Operational Context



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Interoperability / Net-Ready KPP Testing Problem

- Cost prohibitive, and sometimes impossible, to locate all required systems in one place
  - Laboratory and simulated representations may be the only assets available
  - Systems and their representations are distributed throughout the U.S. (industry, test ranges, government laboratories)

- Difficult, time-consuming, and expensive to plan and execute distributed test events
  - Networks require time-consuming security agreements to be coordinated
  - Instrumentation data definitions differ from laboratory to laboratory
  - Lack of universal tools complicates test integration
  - Distributed test events require engineering each and every time

Interoperability and Net-Ready KPP difficult to test extensively or early in acquisition

JMETC PROGRAM OVERVIEW

What is JMETC?

- A corporate approach for linking distributed facilities
  - Enables customers to efficiently evaluate their warfighting capabilities in a joint context
  - Provides compatibility between test and training
- A core, reusable, and easily reconfigurable infrastructure
  - Consists of the following products:
    - Persistent connectivity
    - Middleware
    - Standard interface definitions and software algorithms
    - Distributed test support tools
    - Data management solution
    - Reuse repository
- Provides customer support team for JMETC products and distributed testing

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JMETC Supports:

- Testing across full spectrum of acquisition process
  - Developmental Test, Operational Test
  - Interoperability Certification
  - Net-Ready KPP compliance
- Joint mission portfolio testing
- Evaluation of weapons systems in joint mission environment
- Conduct of live, virtual or constructive testing
- Conduct of joint testing and training

Used whenever you need to link resources together to conduct a distributed test event

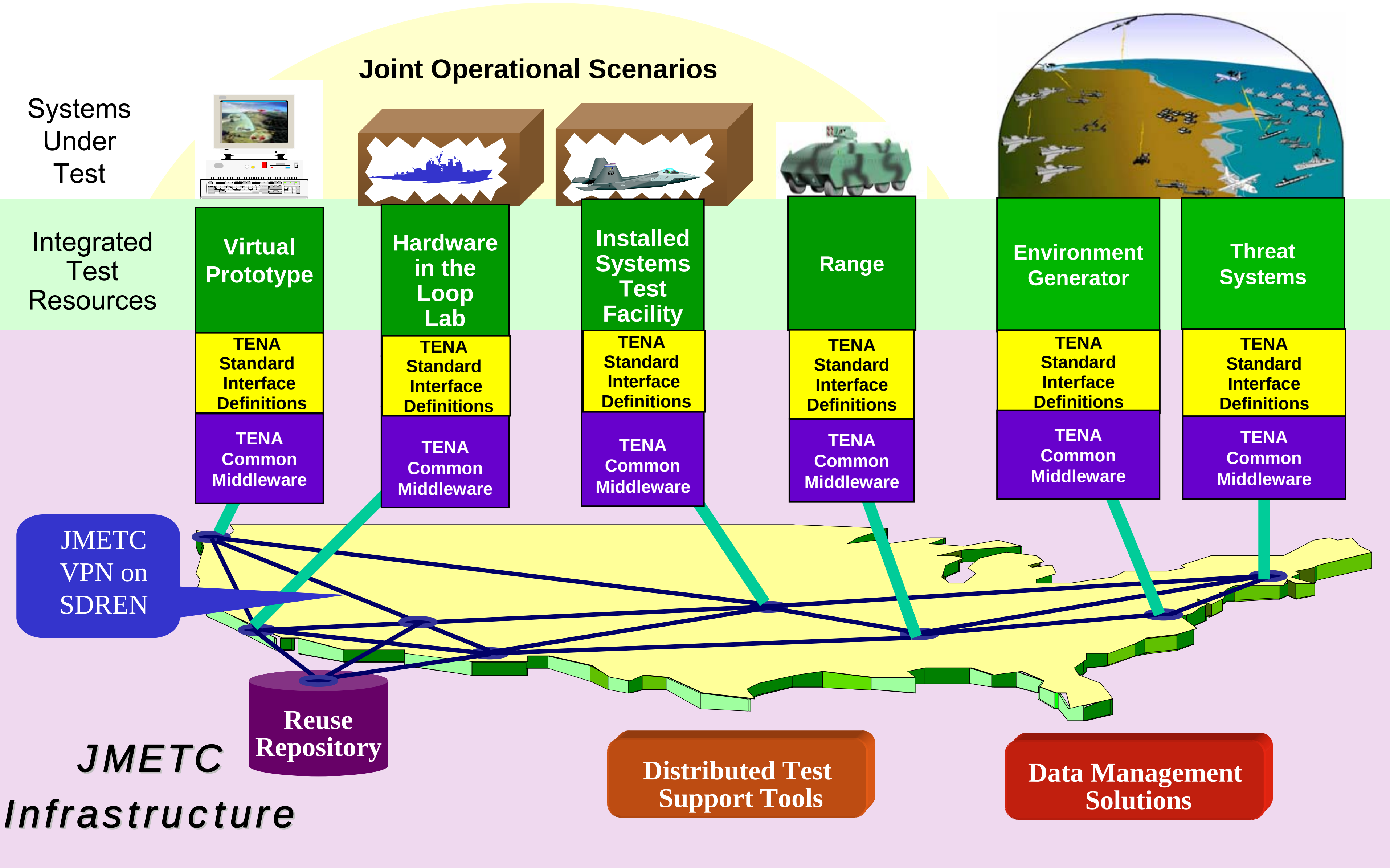
JMETC Infrastructure (1 of 2)

- **Persistent connectivity**
  - Readily available network configured for exchanging test data over existing DoD data transport capabilities
  - Solution: Initial VPN has been established and is operational on the Secure Defense Research and Engineering Network
- **Standards for Components / Interfaces**
  - A collection of interface definitions and software algorithms (e.g., Radar, TSPI, coordinate conversions, unit conversions, etc.) that provide a common language used in data exchanges between systems
  - Solution: Use TENA and upgrade per requirements from Users Group
- **Middleware**
  - Universal data distribution software used by every node to send and receive data
  - Solution: Use TENA and provide gateways to connect to other data protocols

JMETC Infrastructure (2 of 2)

- **Distributed Test Support Tools**
  - A collection of common software applications that assist test engineers to plan, prepare, set-up, check-out, monitor, and analyze the distributed test event
  - Solution: JMETC will do a best of breed search for test support tools with final recommendations made by the JMETC Users Group
- **Data Management Solutions**
  - A suite of data archiving solutions to store test data collected at multiple locations enabling efficient data collection and analysis for events
  - Solution: CTEIP study to develop roadmap in FY 08 with follow-on CTEIP project to develop solutions
- **Reuse Repository**
  - An on-line web portal with relevant distributed event information (latest middleware, software components, documentation, lessons learned, meta-data) and web-enabled collaboration services
  - Solution: Establishment of www.jmetc.org for re-use repository in FY08

JMETC Enabled Distributed Testing



JMETC Customer

- **Program Manager (PM)**
  - Examples include: Acquisition Program Managers, Portfolio Managers, Advanced Concept Technology Demonstration (ACTD) Managers, etc.
- **Test Agent**
  - Organizations designated by PMs to lead their event test planning and execution (e.g. White Sands Missile Range (WSMR) and Edwards AFB)
- **Resource Owners (Owners of Test Resources)**
  - Capabilities **owned across the Department and <u>in industry</u>** that test warfighting capabilities (e.g., Air Combat Environment Test & Evaluation Facility (ACETEF))
  - Test Resources include: simulations, measurement facilities, System Integration Labs, Hardware-in-the-Loop Labs, installed systems test facilities, open air ranges

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JMETC Customer Support

JMETC supports customer needs at customer request

Technical Expertise:

- Assists in understanding how to use JMETC products
- Assists in developing T&E strategy and requirements
- Supports event planning, preparation, and execution

Product Support:

- Reviews and certifies JMETC products for corporate use
- Integrates new nodes onto JMETC VPN with security agreements
- Augments DREN with sites critical for joint testing (maximizing reuse)
- Measures JMETC infrastructure performance
- Provides Help Desk to assist JMETC product users
- Provides semi-annual TENA training classes

Prioritization of effort is based on funding available

Customer Responsibility

- **The customer is responsible for:**
  - Defining requirements
  - Providing test facilities and resources
  - Installing TENA in their test facilities and resources
  - Requesting and funding field assistance:
    - Technical integration support, including site verification
    - JMETC product training
    - Detailed event planning, preparation, and execution
  - VPN usage fees (charges coordinated with JMETC Program)
  - Unique middleware, object model, and software tool development and upgrades
- **Sites not on JMETC VPN build plan may fund their own addition to JMETC infrastructure**

Industry Involvement

- **Two ways to participate in the JMETC infrastructure:**
  - Being on government contract to support a program or test event using JMETC
    - Contractor-funded sites possible depending on priorities and resources
  - Participate in the JMETC Users Group
    - Next meeting tentative for January 2008, location TBD
- **TENA Architecture Management Team (AMT)**
  - Technical forum providing open dialogue between users and TENA developers
    - Next meeting tentative for January 2008, location TBD
  - Used to identify issues, vet concerns, debate solutions, and agree on way forward
  - Over 27 companies currently are members of TENA AMT
  - TENA middleware/object models freely available (www.tena-sda.org)

Industry is a key component in a successful DoD "corporate approach" to linking distributed facilities

JMETC Leadership & Governance

JMETC Chain of Command

Honorable John Young
USD(AT&L)

Dr. John B. Foulkes
Director, Test Resource Management Center (TRMC)

Richard L. Lockhart
Principle Deputy, TRMC
Deputy Director, JIPP

Chip Ferguson
JMETC Program Manager

George Rumford
Systems Engineering Lead (Acting)

JMETC Governance

Testing in a Joint Environment Senior Steering Group

- Senior DoD Leaders
- Status: Charter Drafted

JMETC Advisory Group

- Service/Agency reps
- Regularly held meetings to discuss/review plans, common issues, needed studies, etc.

JMETC Users Group

- Technical representatives of customers and test resource owners
- Two meetings held in FY07
- ~150 participants/meeting

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JMETC Benefits

- **Provides Department-wide capability for:**
  - Evaluation of a weapon system in a joint context
  - DT, OT, Interoperability Certification, Net-Ready KPP compliance testing, Joint Mission Capability Portfolio testing, etc.
- **Provides test capability aligned with JNTC**
  - Both use TENA architecture
  - Enables joint test and training
- **Reduces time and cost by providing**
  - Readily available, persistent connectivity with standing network security agreements
  - Common integration software for linking sites
  - Distributed test planning support tools
- **Provides distributed test expertise**

The corporate solution to distributed LVC Testing

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FY 07 JMETC ACCOMPLISHMENTS

JMETC Accomplishments – FY07
Summary (1 of 2)

- Established JMETC Program Office October 2006
- Completed the Program Execution Guide briefing to assist customers
- Conducted a DoD Distributed Test Infrastructure Assessment (requested by Joint Staff J8)
- Initiated development of the JMETC Reuse Repository
- Established JMETC Advisory Group
  - Held regular meetings to discuss activities
- Established JMETC Users Group
  - First Meeting, Jun 19-20 with 140 attendees
    - SIAP, JSF, and FCS briefed their plans
  - Second Meeting, 14-15 Aug with 150 attendees
    - Navy DEP briefed their plans
  - Focus groups established for:
    - User Requirements, Tools, InterTEC Spiral 2, Networks, and Data Standards

JMETC Accomplishments – FY07 Summary (2 of 2)

- Initiated collaboration with the Training community
  - Used the JNTC-sponsored network aggregator in first test event supported by JMETC
  - Initiated effort to peer JNTC JTEN with JMETC VPN
  - Established the JNTC JATTL as a beta-test site for next version of TENA (TENA 6.0 will be release in FY08)
  - Supported the JFCOM LVC Architecture Roadmap Study
- Stood up the JMETC VPN on the SDREN
  - Established 8 locations on the JMETC VPN available for future use
    - Pax River, Eglin, White Sands, Redstone, China Lake, Pt. Mugu, Pt. Loma, and JITC
- Supported two distributed test events
  - Integral Fire 07
  - InterTEC Spiral 2 Build 1

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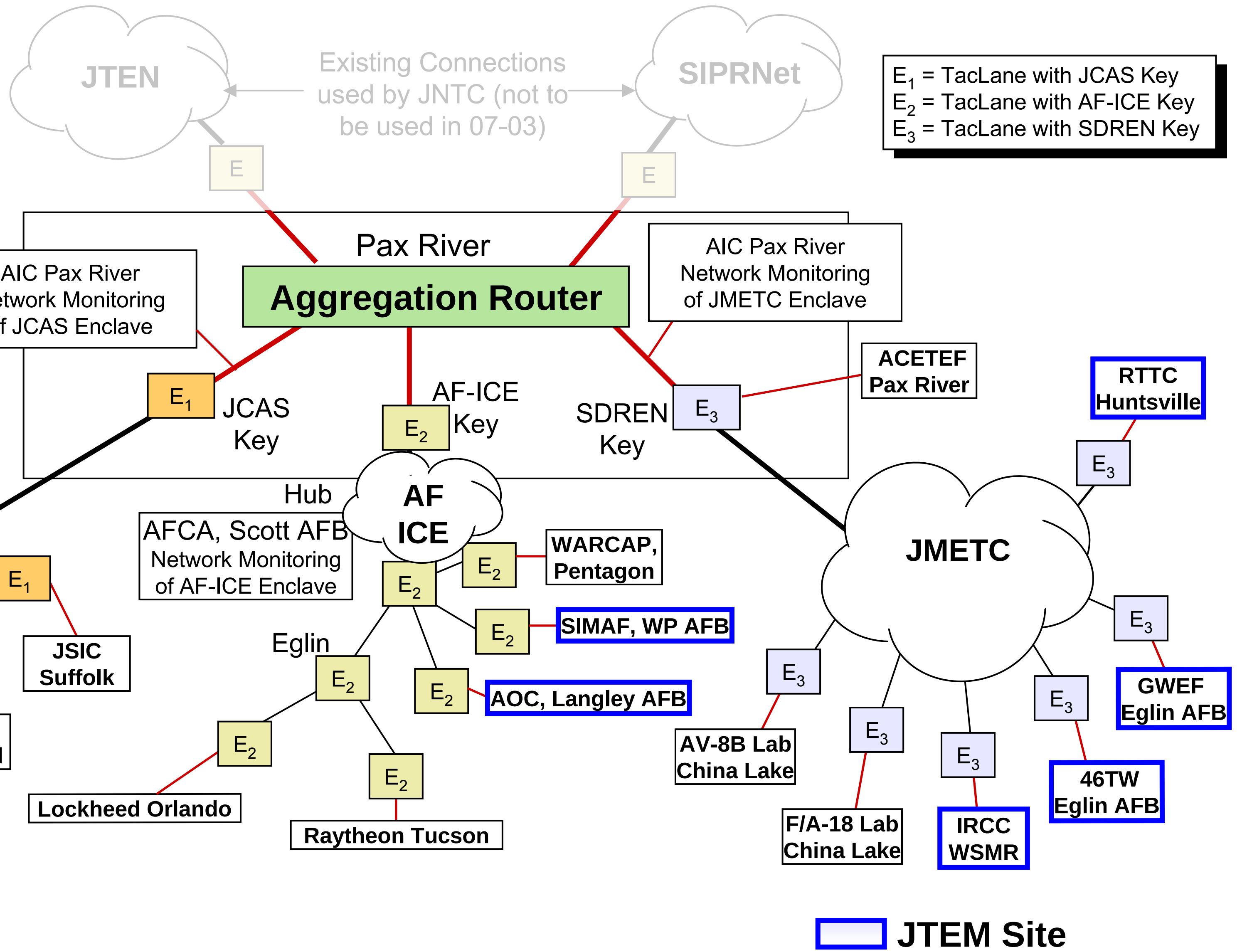
JMETC FY 07 Accomplishments

Integral Fire 07 Test Event

- Integral Fire 07 Description:
  - A combined, distributed test event conducted in August 07 supporting the following three customers:
    - JFCOM JSIC JCAS Assessment
    - JTEM Methodology Assessment
    - USAF Warplan-Warfighter Forwarder (WWF)
- JMETC Responsibilities:
  - Overall lead for creating the distributed test Infrastructure including JMETC VPN (5 locations)
  - Connect three enclaves (total of 15 locations) using the JFCOM aggregator router
  - Conduct systems integration, site surveys, and dry runs
  - Oversee operation of the network and data flow among all sites during the event
- JMETC Significant Accomplishments:
  - Stood up and successfully demonstrated the JMETC VPN within 90 days
  - Successfully used the Aggregation Router to link three enclaves
  - Supported three customers conducting tests using the same network in the same time frame

Integral Fire Infrastructure



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JMETC FY 07 Accomplishments
InterTEC Spiral 2, Build 1 Test Event

– InterTEC Description:
  - Interoperability T&E Capability (InterTEC) is an OSD-sponsored, Navy-led project under the Central T&E Investment Program (CTEIP)
  - Purpose is to develop an accredited test capability to conduct joint interoperability certification and joint mission thread testing

– Spiral 2, Build 1 Objectives:
  - Developing and assessing tools to test joint threads
  - Assessing the C2 messages sent from sensors to shooters through command and control systems (GCCS-J, GCCS-M, GCCS-A, and TBMCS)

– JMETC Responsibilities:
  - Overall lead for creating the Infrastructure integrating 6 locations
  - Conduct systems integration, site surveys, and dry runs in preparation for the event
  - Oversee operation of the network and data flow among all sites during the event

– JMETC Significant accomplishments
  - Established the new locations on the JMETC VPN within 90 days
  - Demonstrated re-use (three locations from Integral Fire 07 test)
  - Successfully used the Aggregation Router

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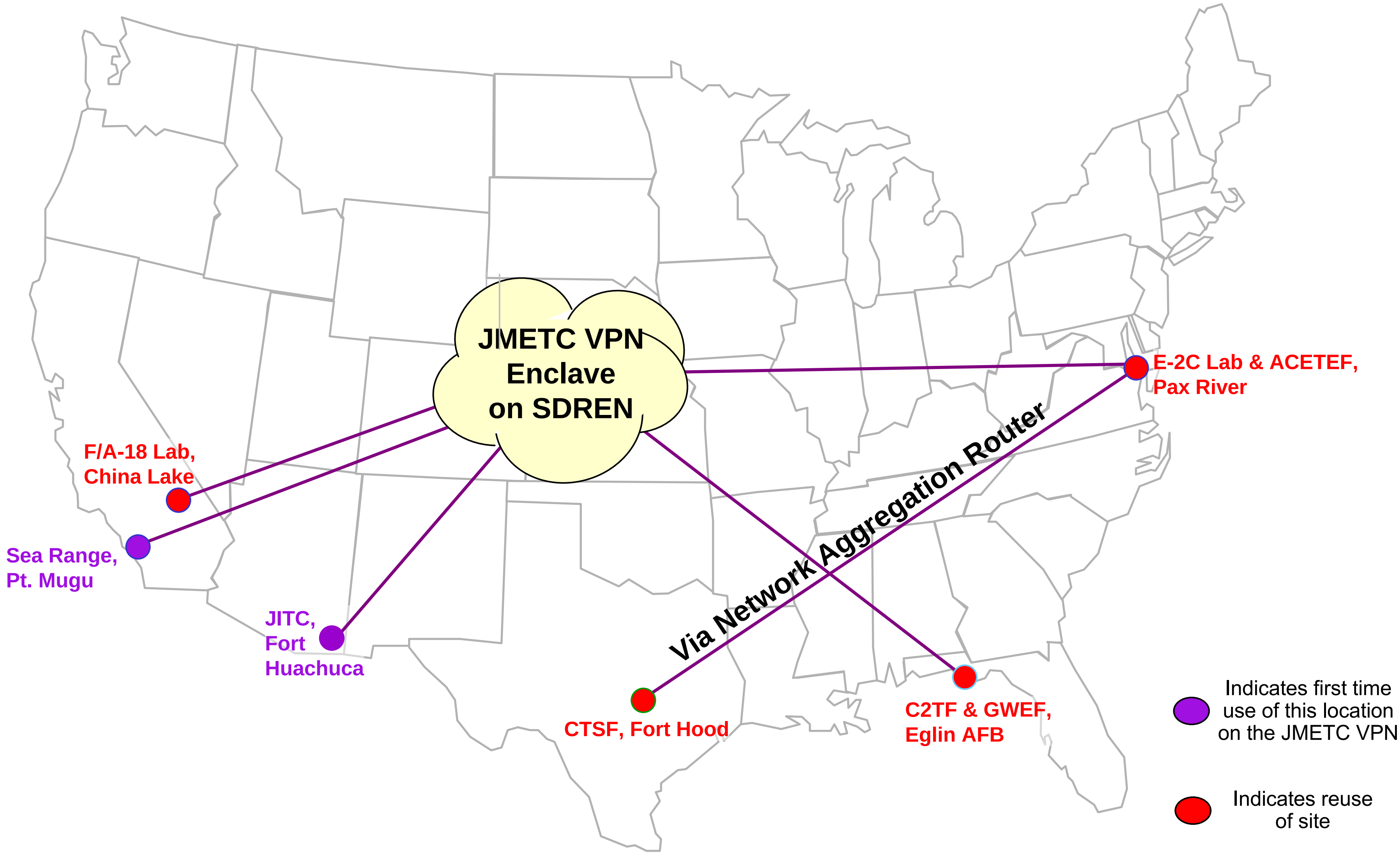
JMETC Support for InterTEC Spiral 2 Build 1



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JMETC FY 08 PLAN

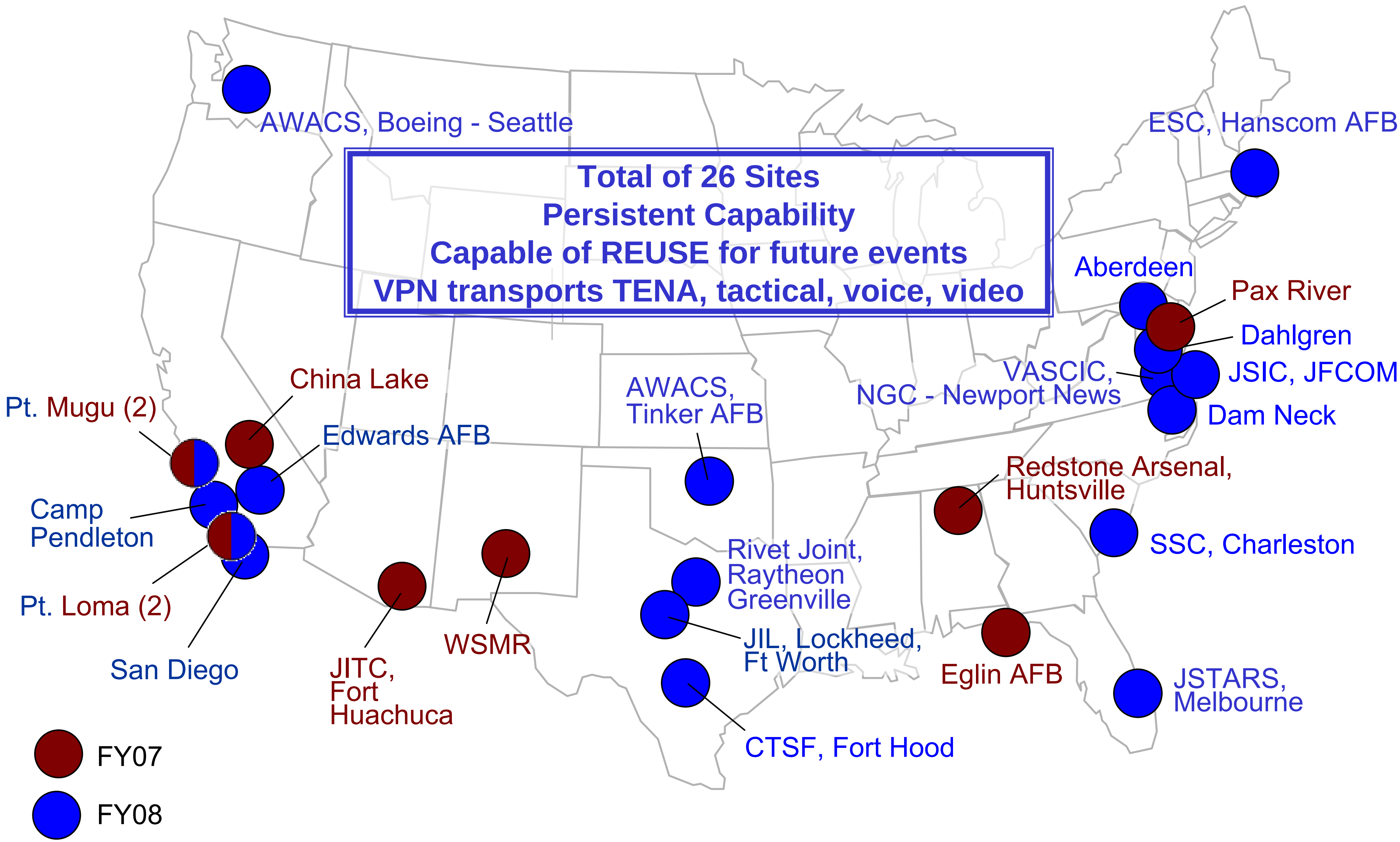
FY 08 Plan

- Complete hiring for government positions
- Publish Program Execution Guide (handbook)
- Expand JMETC Infrastructure
  – Expand the JMETC VPN per customer requirements and potential for reuse
  – Add 18 locations for a total of 26 available for reuse by the end of FY 08
- Initiate JMETC Reuse Repository at www.jmetc.org
- Hold quarterly JMETC Users Group and JMETC Advisory Group meetings
- Publish Newsletter
- Collaboration with Training Community
  – Continue to collaborate on common distributed test and training infrastructure requirements
  – Continue to support the JFCOM led LVC Architecture Roadmap Study
  – Demonstrate JTEN and JMETC VPN peering capabilities

FY 08 Plan
(continued)

- Support Other JMETC-related Activities
  - JTEM JT&E
  - Support 3 studies resulting from the Distributed Test Infrastructure Assessment
    - Transitioning Test Capabilities to Internet Protocol version 6 (IPv6)
    - Determining the Applicability of a SOA to Support Distributed Testing
    - Determining Test Infrastructure Needed to Test Warfighting Capabilities Using the GIG
- FY 08 Event Support
  - InterTEC Spiral 2, Build 2 and System Acceptance Test (SAT)
    - Spiral 2, Build 2 scheduled in April/May 08 followed by the SAT in June 08
    - Test OTH-G messages using a Joint Fires Scenario
    - Integrating 12 locations
    - May include CVN-21 participation
  - FCS Combined Test Organization
    - Experiment and test of the infrastructure needed to evaluate joint functionality of FCS
    - Jun-Aug 08 (tentative)
    - Planning to adhere to JTEM Methods and Processes
  - SIAP
    - Risk reduction test for a planned Oct 08 event

JMETC VPN Locations (FY07-08)



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Summary

- JMETC Program Office stood up
- JMETC VPN established – 26 locations available for reuse by the end of FY 08 based on customer requirements
- Successfully supported two test events in the first year
- Coordinating with JFCOM to bridge test and training capabilities
- Collaborative effort with the Services and Industry
- Multiple programs requesting support
  – SIAP, FCS, CVN-21, JSF, MMA

JMETC IS THE CORPORATE SOLUTION FOR JOINT DISTRIBUTED TESTING AND IS AVAILABLE NOW

Points of Contact

Program Manager: Chip Ferguson
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Systems Engineer: George Rumford
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Maintaining System Viability for the Long Term

Paladin/FAASV Integrated Management (PIM)

10th Annual NDIA Systems Engineering Conference
San Diego, California

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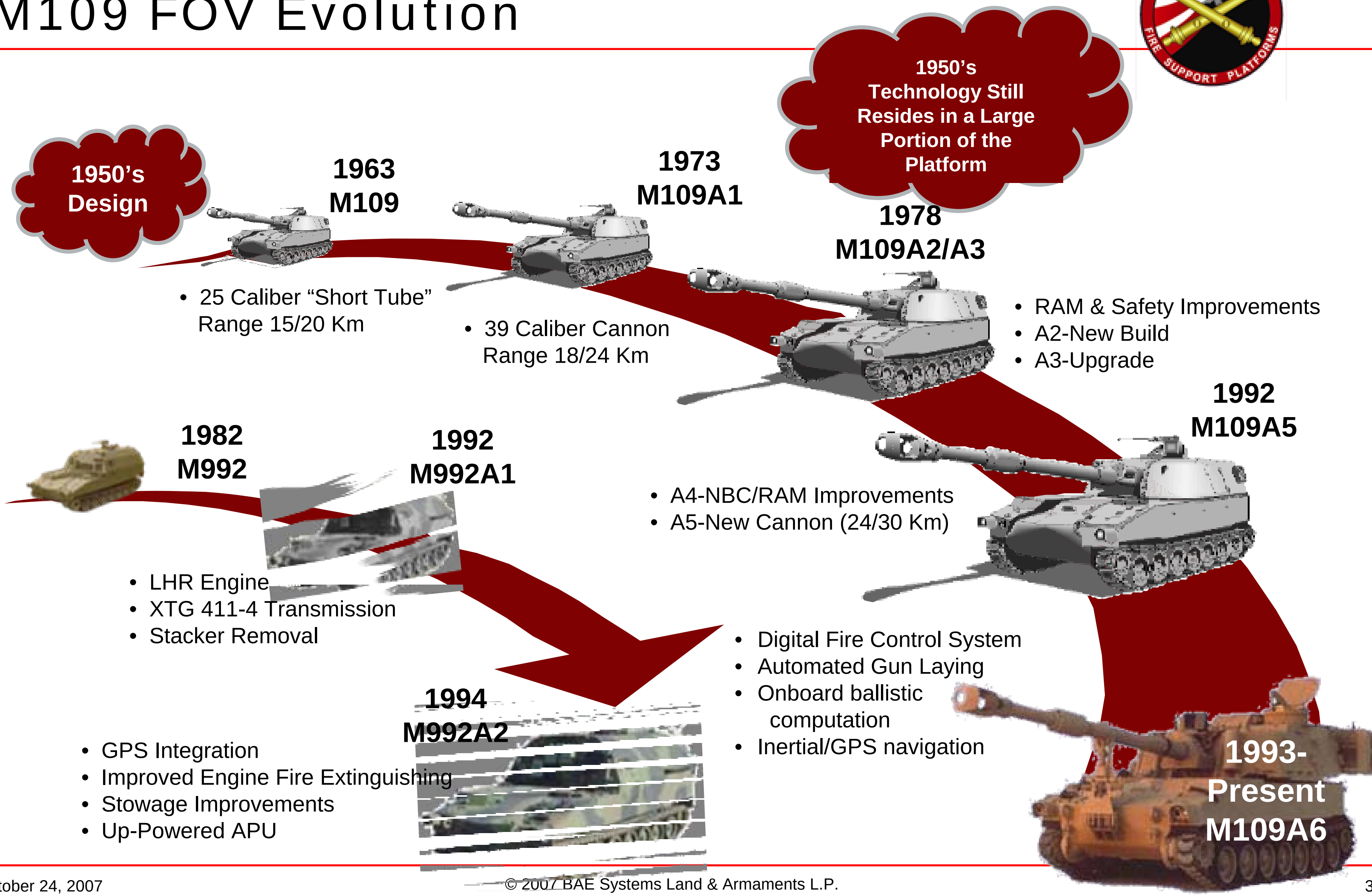
Contents

- M109 family of vehicles
- The rise of sustainability/support issues
- Synchronizing goals
- Paladin/FAASV Integrated Management (PIM)
- Project organization
- Engineering challenges
- Conclusion

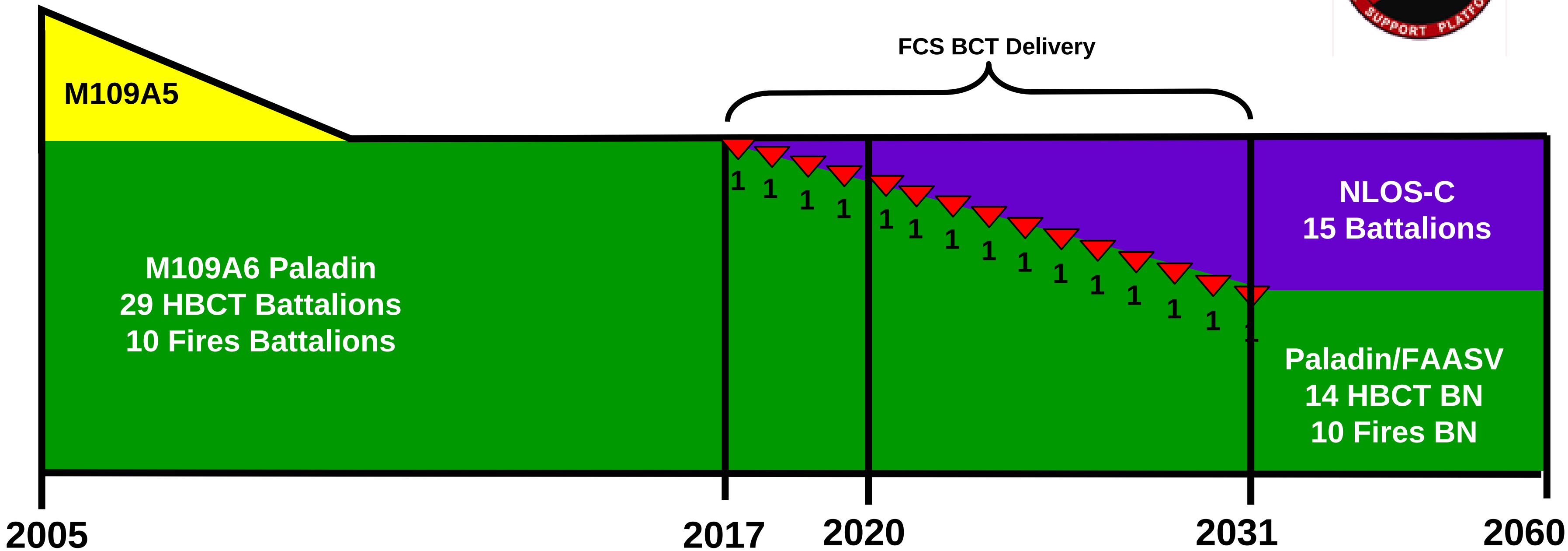
M109 FOV Evolution



Changing Environment

- Through the 1990's the expectation was that Crusader and Re-Supply vehicle would replace the Paladin/FAASV by 2008
- Long-term design sustainment of the M109 FOV was not required
- In 2002, the Future Combat Systems Non-Line of Sight Cannon (NLOS-C) replaced the Crusader in Army development plans; M109 family was still expected to be supplanted by NLOS-C
- Army Decision Point 41.1 dictated a path to a modular force comprised of a mix of current force and future force components, with platforms viable and sustainable through 2050
- Long-term sustainment of Paladin again became a requirement

SPH Distribution Plan



- **Fully Sustainable Paladin/FAASV Baseline required to support the HBCT**
- **Must be Interoperable With Future Force – Will fight together**
- **Must keep pace with Bradley & Abrams – maintain operational relevance**

Significant challenges with obsolescence; very limited growth potential;
On the verge of becoming unsustainable

Trends & Drivers

- **Downward Readiness Trend:**
  -

	Total Army	Average
	FY04-05	93.1%
	Last 12 Mos	90.7%

  - Data Gathered From Logistics Integrated Database (AMSAA)
- **Vehicle Age Versus Maintenance Costs and Burden (14 yrs vs. 8 yrs)**
  - 73% Increase in Maintenance Costs
  - 142% Increase Maintenance Burden
  - Data Gathered From SDC at Ft. Stewart & Ft. Hood

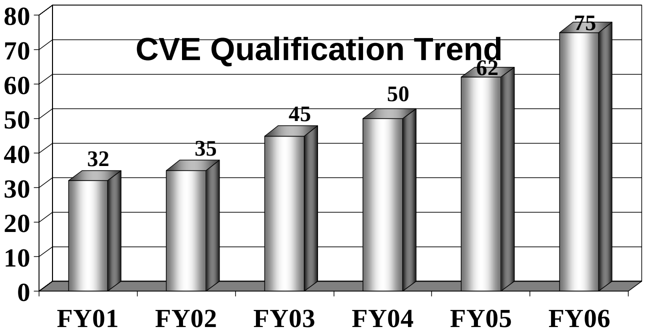
Decreases at 5 of 6 Location For Last 12 Months

Europe	NG	FORSCOM	2ID	SWA	TRADOC
92.7%	95.2%	93.4%	92.6%	89.0%	92.3%
94.1%	92.3%	91.3%	87.8%	86.4%	73.8%

Ft. Stewart	Ft. Hood	NTC
94.7%	91.1%	90.4%
93.7%	90.5%	88.6%

Location	Ft. Hood	Ft. Stewart
Vehicle Age	14 yrs	8 yrs
* Maint Action Per Year	24	14
Manhour Per Maint Action	9.8	7.2
* Maint Cost Per Year	$11,754	$6,798
* Maint Manhour Per Year	235.2	97.2

*** Based on 600 Mile OPTEMPO Per Year**



Sustainability: Paladin/FAASV Component Age

- **Vehicle Chassis and Major Component Designs Over 45 Years Old (TDP developed in late 1950's/early 1960's)**
- **Vehicle Design Life 20 Years**
- **M109 First Fielded in 1963**
  - All M109A6 Paladins Built on Refurbished M109 Chassis
- **M109 Major Component Age**

Basic M109 – Circa 1965

Average Age

1. **Based on Paladin Production Data at York/LEAD**
2. **Based on Serial Numbers of Chassis Inducted Into LEAD Production, Analyzed Against OEM Production Records (A2) & Historical Data from TACOM (A0 & A1)**

			Calendar Year		
			2006	**2025**	**2050**
Average Age	**Cab / Paladin Unique Items** [1]	**1990's Design** (Post Desert Storm)	**9**	**28**	**53**
	Chassis / Re-Used Parts [2] **e.g.** ▪ **Chassis Structure** ▪ **Transmission** ▪ **Road-Arms** ▪ **Final Drives** ▪ **Rammer / Elevating Cylinder**	**1960's Design** (Vietnam Era)	**36**	**55**	**80**

Perspective

- Competing priorities have limited Army/OEM investment in Paladin
- HBCT-centric approach brings focus & visibility
  - Three legs to the stool – Tanks, Bradleys & Paladin
  - Acknowledgement that like Bradley & Abrams, Paladin will be in the fleet for foreseeable future
- Efforts coming together – positioning program
  - Dedicated program to maintain fleet at acceptable average age
  - Formal establishment of “Paladin Integrated Management” (PIM) line
- Sync between Combat Developers, Material Developers & OEM

BAE SYSTEMS

Prioritized Goals

- PM Priorities
- Support the fight
  - Reset
  - Excalibur
- Sustain the fleet
  - PDFCS/APU/MACS Retrofit
  - RESET/RECAP
  - Mitigate Obsolescence
- Build the future
  - Modularity fieldings
  - Develop PIM program
  - Spin-out / tech insertion

~ Sep 06

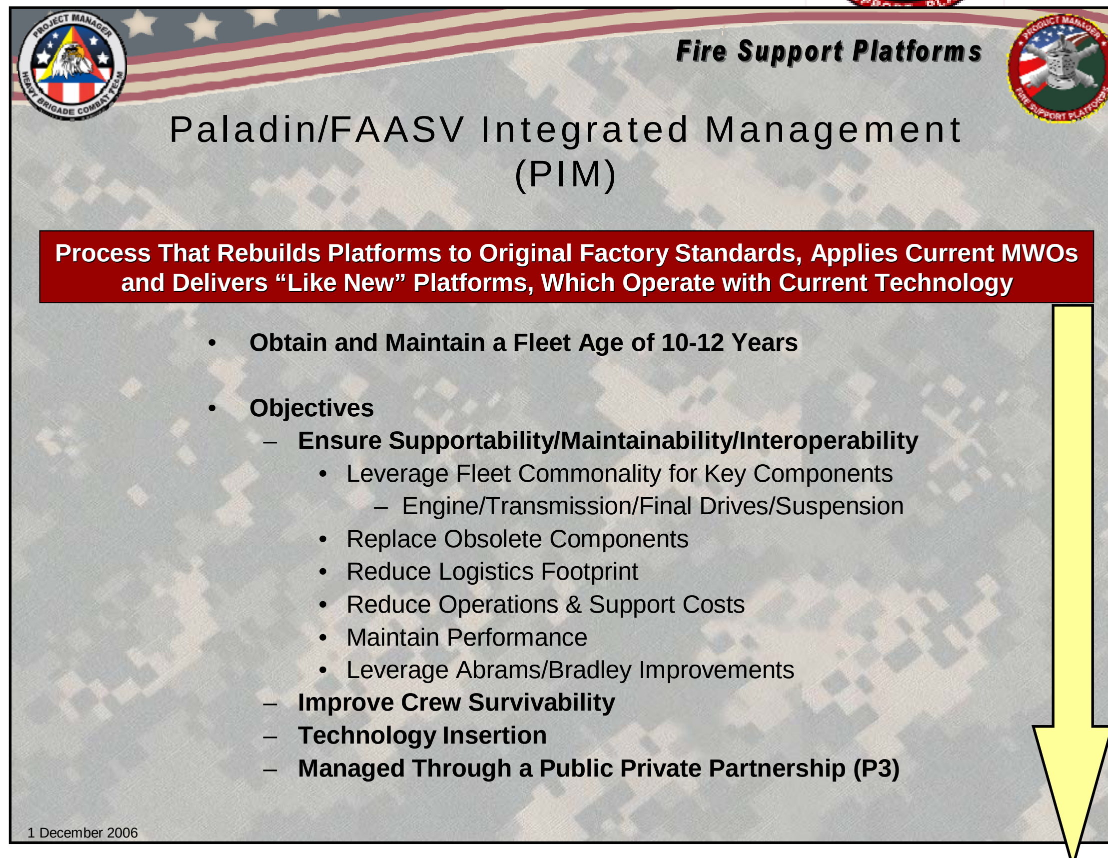
TCM Priorities

- Survivability
- Power train
- Suspension
- Power Management
- Digital communications (cab - hull)
- Rammer Improvements
- Vehicle Health Management

Challenge: convert 1-N list into manageable Army program

Paladin Integrated Management (PIM)

- Specific program & plan to address long-term viability of Paladin
- Keyed to HBCT (read Bradley) commonality
- Leverages FCS/NLOS technologies as appropriate


Fire Support Platforms

Paladin/FAASV Integrated Management (PIM)

Process That Rebuilds Platforms to Original Factory Standards, Applies Current MWOs and Delivers “Like New” Platforms, Which Operate with Current Technology

- **Obtain and Maintain a Fleet Age of 10-12 Years**
- **Objectives**
  - **Ensure Supportability/Maintainability/Interoperability**
    - Leverage Fleet Commonality for Key Components
      - Engine/Transmission/Final Drives/Suspension
    - Replace Obsolete Components
    - Reduce Logistics Footprint
    - Reduce Operations & Support Costs
    - Maintain Performance
    - Leverage Abrams/Bradley Improvements
  - **Improve Crew Survivability**
  - **Technology Insertion**
  - **Managed Through a Public Private Partnership (P3)**

1 December 2006 3

Process That Rebuilds Platforms to Original Factory Standards, Applies Current MWOs and Delivers “Like New” Platforms, Which Operate with Current Technology

PIM Strategy

- Many Issues are Inter-Related; Requires Total Weapon System Approach (vice individual efforts to solve point problems)
- PIM Strategy IAW DP 41 (Viable & Sustainable Platforms beyond 2050)
- Provide Viable Life-Cycle Solution Beyond 2050
- Design, Test, and Qualify an Affordable Alternative Structure Around Selected Components
- Current Planning Leverages Commonality With HBCT e.g.
  - Bradley Common Track, Engine, Transmission, etc
  - Eliminate Hydraulics (Except Recoil System)
  - Vehicle Health Management
  - Reduces Logistics Footprint, O&S Costs & Development Time/Cost

Rebuilds Platform, Applies Current Modification Work Order's (MWO) and Delivers a Ready, Relevant and Sustainable Platform

BAE SYSTEMS

PIM Howitzer Features

Achieving Sustainability via HBCT Commonality

LEGEND
- Bradley Common
- NLOS common
- Common Modular Power System
- Paladin/FAASV

ISCS - Individual/Spot Cooling System (improved MCS)

CREW 2

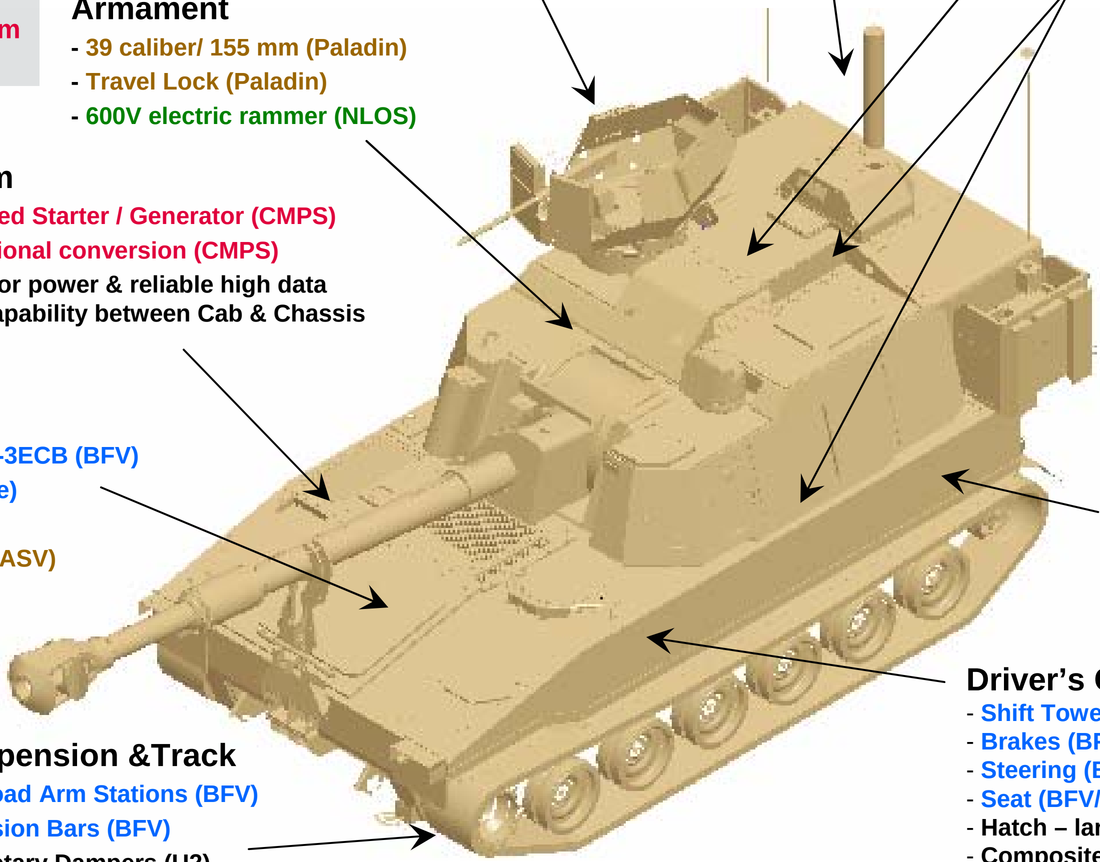
COS Cupola TAGS

Armament
- 39 caliber/ 155 mm (Paladin)
- Travel Lock (Paladin)
- 600V electric rammer (NLOS)

Gun Drives
- Integrated with PDFCS
- 600V Electric Elevation drive (NLOS)
- 600V Electric Traverse drive (NLOS)
- Electric Joysticks
- Manual Gun Drive backups

Electrical System
- 600V, 70 kW Integrated Starter / Generator (CMPS)
- 600V – 28V Bi-Directional conversion (CMPS)
- Cable Management for power & reliable high data transmission capability between Cab & Chassis

Electronic Systems
- PDFCS
- DRU-H
- VHM



Power Train
- Engine 600 HP (BFV)
- Transmission HMPT 500-3ECB (BFV)
- PTO (upgraded BFV-style)
- New Cooling system
- Engine Compt AFES (FAASV)
- Final drive (BFV)

Blue Force Tracking
- P3I for BFT

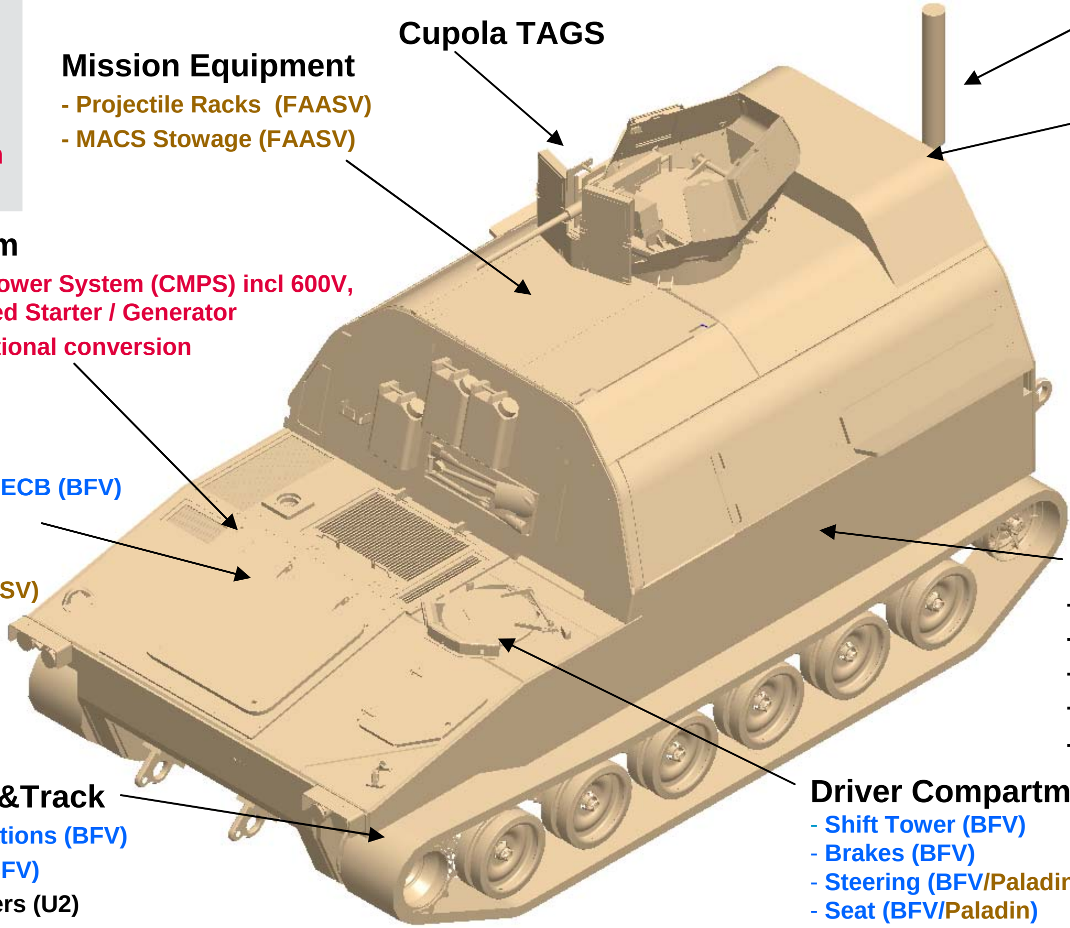
Chassis (new structure)
- Additional ground clearance
- Structure integrity (71500 lbs GVW)
- Provisions for Mine Blast kit and side Armor

Suspension &Track
- 6 Road Arm Stations (BFV)
- Torsion Bars (BFV)
- 4 Rotary Dampers (U2)
- Track 19.1” (BFV)

Driver’s Compartment
- Shift Tower (BFV)
- Brakes (BFV)
- Steering (BFV/Paladin)
- Seat (BFV/Paladin)
- Hatch – larger diameter than Paladin
- Composite Armor
- Instrument Panel (BFV/M109 & Digital Display)

PIM-FAASV Features
Maximal commonality with PIM Howitzer

LEGEND
- Bradley Common
- NLOS common
- Common Modular Power System
- Paladin/FAASV



Cupola TAGS

Mission Equipment
- Projectile Racks (FAASV)
- MACS Stowage (FAASV)

CREW II

ISCS - Individual/Spot Cooling System (improved MCS)

Electrical System
- Common Modular Power System (CMPS) incl 600V, 70 kW Integrated Starter / Generator
- 600V – 28V Bi-Directional conversion

Crew Compartment
- Crew seating (FAASV)
- Rear door (FAASV)
- Crew AFES (FAASV)

Power Train
- Engine 600 HP (BFV)
- Transmission HMPT 500-3ECB (BFV)
- PTO (upgraded BFV-style)
- New Cooling system
- Engine Compt AFES (FAASV)
- Final drive (BFV)
- Easily accessible Air Cleaner Filter

Blue Force Tracking
- P3I for BFT

Chassis (new structure)
- Lower Chassis common with SPH
- Provisions for Mine Blast kit & Side Armor
- Additional ground clearance
- Flat Floor in rear
- Structure integrity (71500 lbs GVW)

Suspension &Track
- 6 Road Arm Stations (BFV)
- Torsion Bars (BFV)
- 4 Rotary Dampers (U2)
- Track 19.1” (BFV)

Electronic Systems
- Power Management (CMPS)
- VHM

Driver Compartment
- Shift Tower (BFV)
- Brakes (BFV)
- Steering (BFV/Paladin)
- Seat (BFV/Paladin)
- Hatch – larger diameter
- Composite Armor (Paladin)
- Instrument Panel (BFV/M109 & Digital Display)

IR&D Prototype – October 2007

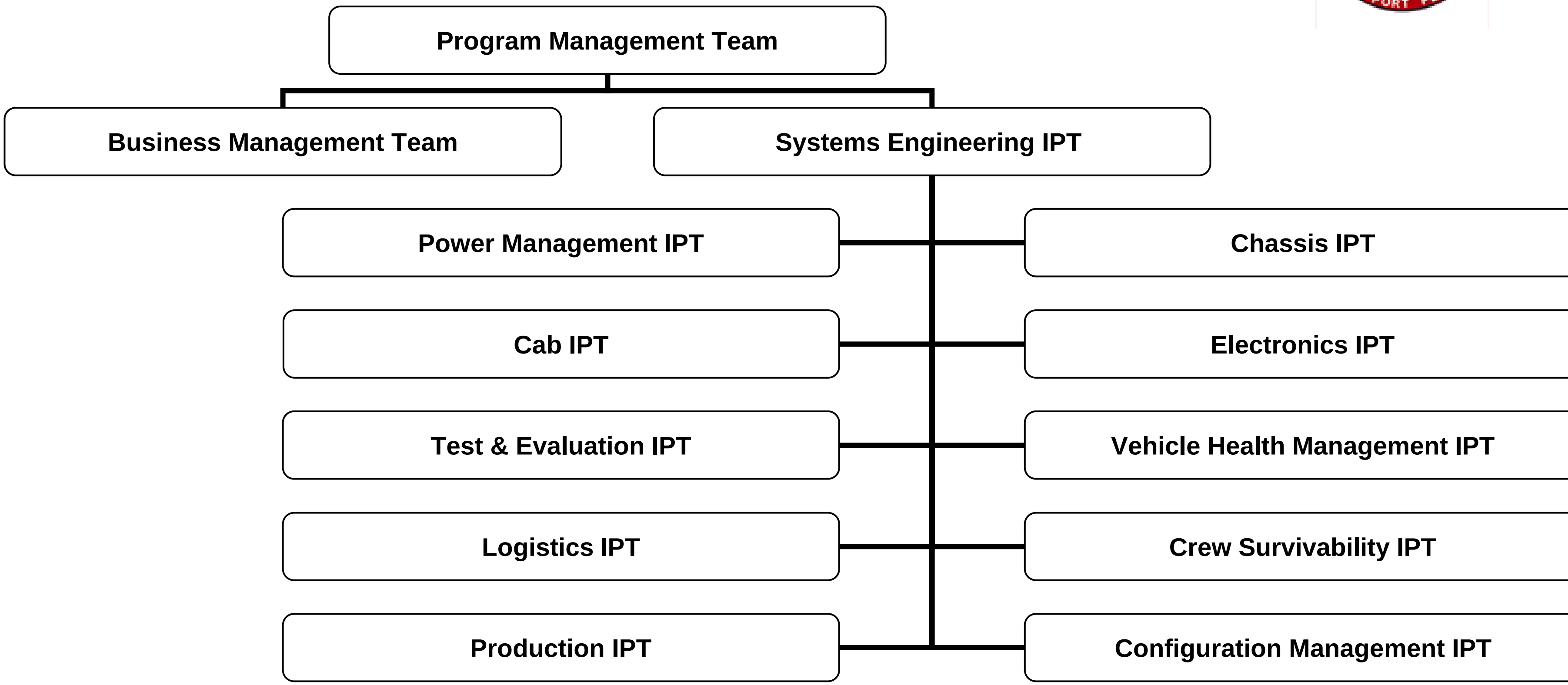
PIM System Development Approach

- Total system approach vs. point solutions for individual problems (typical STS task order-approach)
- Design approach is that of a Systems Integration problem vs. a development problem – IPTs to use HBCT-common solution where one exists
- HBCT commonality of subsystems provides lower development and acquisition costs than a new unique design

Public-Private Partnership: Industry-Government collaboration with common goals & objectives sharing successes and failures

BAE SYSTEMS

PIM IPT Hierarchy



- Each IPT is jointly chaired by Government and Industry leads
- Core and ad hoc / supporting members are identified in IPT charters
- IPT Core membership includes key suppliers

SE Challenges in a Sustainment Project

- Baseline Requirements Set may be Incomplete
  - e.g., off-road mobility requirement not explicitly defined
- User can Become Accustomed to or Reliant on Features that are not Defined in the Requirements Baseline
- Design Baseline Documented to Old Documentation Standards
  - e.g., DOD-STD-1679 Software Documentation
  - e.g., Ada Programming Language
- Design Baseline Developed and Tested using Lower-Maturity Processes and Standards
- Performance baseline developed to old mission profiles
  - e.g., Fulda Gap vs. SW Asia
  - May Require Updated or New Mission Profiles

Summary

- PIM leverages components, systems and proven technologies available today to ensure that the Paladin/FAASV fleet remains ready, relevant and sustainable beyond 2050
- HBCT commonality reduces development, acquisition and sustainment costs
- The PIM Public-Private partnership leverages the strengths of both public and private sectors in an open, collaborative process

Partnering for the Soldier

Paladin Enterprise – Leveraging Best of Public & Private Sectors

Executing a Successful CMMI® Maturity Level 3 SCAMPI℠ for SPAWAR Systems Center Charleston (SSC-C)

Michael T. Kutch, Jr.

SPAWAR Systems Center Charleston (SSC-C)

Head, Intelligence & Information Warfare Systems Engineering Department

National Competency Lead for I/A 5.8

Deputy National Competency Lead for ISR/IO 5.6

Mike Knox

Technical Software Services, Inc.

Director, Implementation and Support

SEI Authorized Instructor

10th Annual NDIA Systems Engineering Conference
October 24, 2007

Improving operational effectiveness through C^4ISR common integrated solutions

Presentation Outline

- ➢Background
- ➢Road to Maturity Level 3
- ➢Appraisal Planning/Execution
- ➢Lessons Learned
- ➢Beyond Maturity Level 3

Systems Center Charleston

Background

Technical Software Services, Inc.

Where We Fit

SPAWAR
Systems Center
Charleston

SPAWAR

Space and Naval Warfare Systems Command

President

non-DoD

Secretary of Defense

Secretary of the Navy

Other DoD

CNO
Fleet Support

ASN (RDA)
Acquisition

NETWARCOM | MARCOR
ADDU for C4I
NAVSEA | NAVAIR

SPAWAR
San Diego, CA

NAVSEA
Washington, DC

NAVAIR
Patuxent River, MD

NAVSUP
Washington, DC

NAVFAC
Washington, DC

SYSCEN
San Diego, CA

SYSCEN
New Orleans, LA

SYSCEN
Norfolk, VA

SFA
Chantilly, VA

SYSCEN
Charleston, SC

Network Centric Enterprise

SEI Partner
TECHSOFT
Technical Software Services, Inc.

What We Do

Connecting the Warfighter

Mission- We enable knowledge superiority to Naval and Joint Warfighters through the development, acquisition, and life-cycle support of effective, integrated C4ISR Information Technology, and Space capabilities.

Vision-
Fully Netted in Three

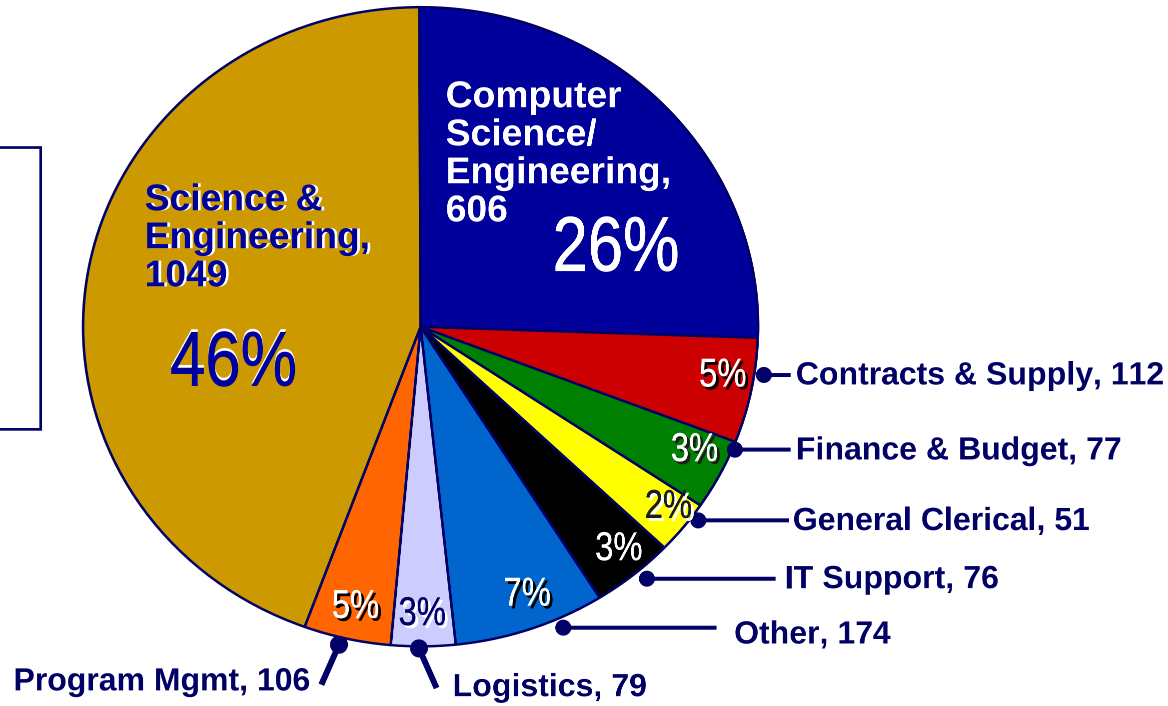
We are the
Principal C4I Acquisition Engineering & Integration Center on the East Coast & Principal C4ISR ISEA for the Navy

Connecting the Warfighter to the resources needed to win GWOT

Who We Are

A Large Systems & Software Engineering Organization

Over 70% of workforce is in an engineering or computer-related discipline



- **The solutions to the global war on terror developed by SPAWAR result from good systems and software engineering**
- **Systems engineering is our core competency**
- **Total workforce of ~ 2,300 employees**

Systems Center Charleston

Road to Maturity Level 3

Implementation of Best Practices

Technical Software Services, Inc.

A Vision of World Class

**When you want it done right,
Who do you want working on it?**

Cutting corners, undisciplined, untrained

Rigorous processes, Skilled resources

Permission to use Redneck Mechanic photo received from Dave Lilligren, 3/9/2007
Permission to use NASCAR Technical Institute photo received from Popular Mechanics, 3/16/2007

Process Improvement and Systems Engineering Strategy - 2003

- **Vision**
  - Develop and maintain a World Class Systems Engineering Organization
- **Approach**
  - Achieve Command-wide operational consistency
  - Based on ISO 15288 – systems engineering
  - Based on ISO 12207 – software engineering
  - Measure using best practices of CMMI®
- **Goals**
  - CMMI Maturity Level 2 by April, 2005
  - CMMI Maturity Level 3 by April, 2007

Both Goals attained on schedule

1st SPAWAR Systems Center to Achieve ML2 and ML3

New Goal: Maturity Level 4 by 2010

Critical Success Factors

CRITICAL SUCCESS FACTORS FOR SE REVITALIZATION	
Command-wide Policy (Create vision that is urgent)	Assign Responsibilities (Strong Change Agents are essential)
Strategy and Plan (Include knowledge of why change is necessary and benefits)	Provide Training
Senior Management Support	Build a Central Repository
Provide Resources and Funding (New Organizational Structure Usually Needed)	Measure and Communicate Progress

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SSC-C SE Revitalization Plan Aligned with DoD SE Revitalization

Elements of SSC-C SE Revitalization

Policy / Guidance

- SSC-C SE Instruction
- SSC-C SE Process Manual
- SSC-C SW-Dev Process Manual
- SSC-C SW-Maint Process Manual
- EPO Website
- ePlan Builder

Training / Education

- Intro to PI WBT
- SE 101 WBT
- SE Fundamentals
- SE for Managers
- Project & Process Workshop
- Intro to Software Engr.
- Architecture Dev. WBT
- Certification/Degrees

Assessment & Support

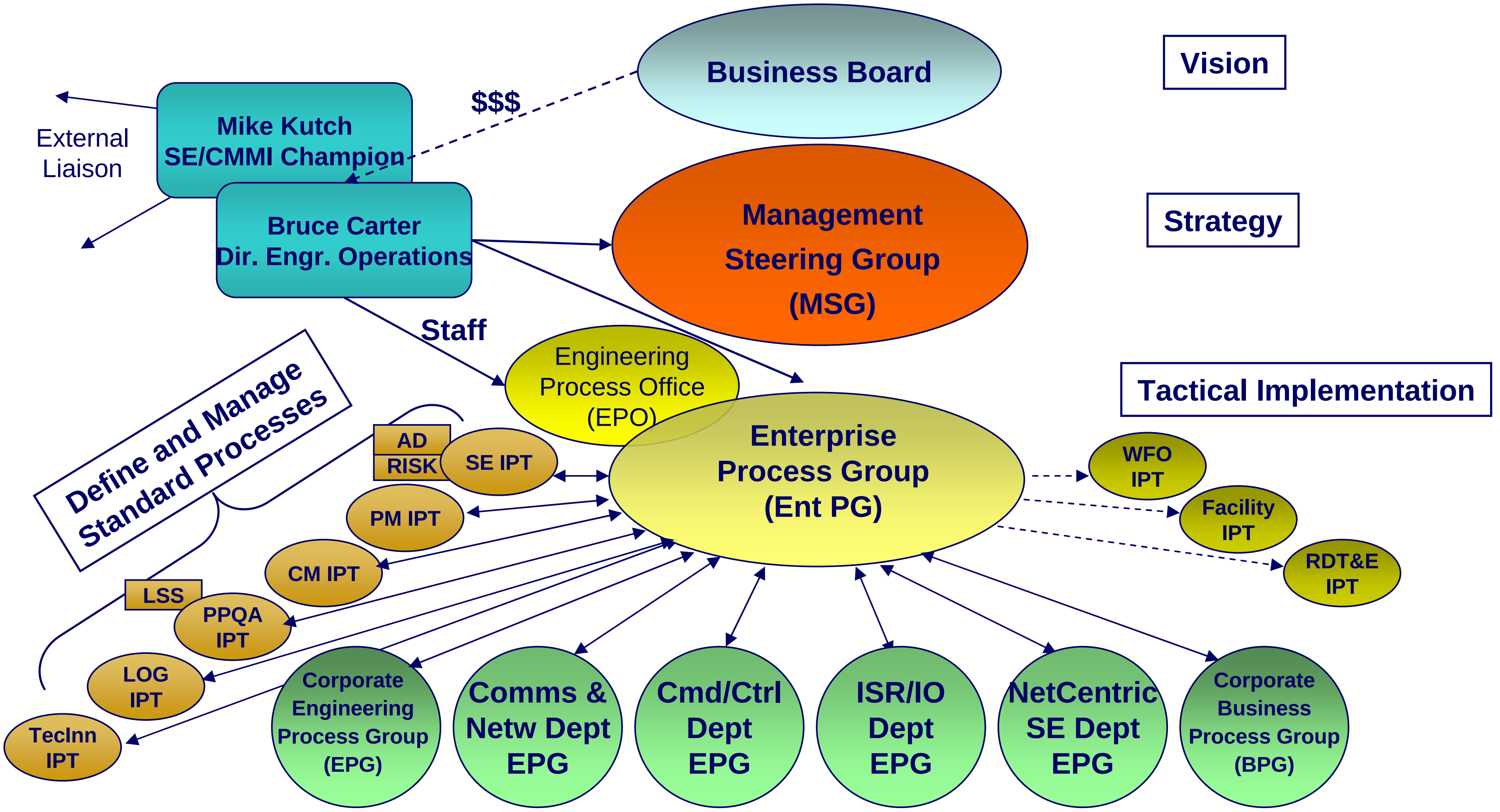
- CMMI® Level 2
- CMMI® Level 3
- CMMI® Level 4/5
- Project Reviews
- Balanced Scorecard
- Lean Six Sigma
- Integrated Product Teams
- IT Tools

Underway

Completed/Ongoing

SEI Partner TECHSOFT Technical Software Services, Inc.

Process Improvement Infrastructure: Organization



Timeline 2001-2002

- **Prior to 2001**
  - Code 70 had experience with SW-CMM®
- **2001**
  - SSC-C Process Improvement (PI) effort began
  - Code 70 developed PI Policy for SE, SW, and Security Engineering using SEI CMM® and CMMI®
  - Code 70 Engineering Process Group expanded to Command-wide
  - Engineering Process Office (EPO) Website started
  - Pilot Projects selected and evaluated
  - Some templates published
- **2002**
  - Began developing and delivering training
  - Began conducting Class "C" assessments as progress checks

Timeline 2003

- **2003**
  - – Established and Funded Dir. of Engineering Operations position
    - Staffed Engineering Process Office (EPO)
  - – Developed Organizational Standard Policies
    - Policy for each CMMI® Level 2 and 3 Process Area
  - – Developed Organizational Standard Process Manuals
    - Top Level
      - Systems Engineering
      - Software Development
      - Software Maintenance
    - Supporting Processes
      - Process Manual for each CMMI® Level 2 and 3 Process Area
  - – Developed plan templates
  - – Coached and mentored pilot projects
  - – Built tools
  - – Developed and delivered training
  - – Performed interim assessments

Timeline 2004-2005

- **2004**
  - – Conducted project-level Maturity Level (ML) 2 SCAMPI℠ Class “A” appraisals
    - 6 Projects Appraised
    - 6 Achieved ML2

- **April 2005**
  - – Conducted Command-level ML2 SCAMPI℠ Class “A” appraisal – First SPAWAR Systems Center to achieve Command-level ML2

The Second Wave – ML2 to ML3[1]

- **Addressed the three Organizational Process Areas early to provide a smoother transition to ML3**
  - *Organizational Process Focus (OPF)* - Purpose: Plan, implement, and deploy organizational process improvements based on an understanding of the current strengths and weaknesses.
    - Determined Process Improvement Opportunities
      - Management commitment – the PI strategy
      - Benchmarked current state, addressed identified needs/gaps
    - Planned and Implemented Process Improvements
      - Determined Scope, Model (CMMI-SE/SW), Approach (Staged, but appraise using Continuous)
      - Created appropriate teams to champion PI efforts
    - Deployed Organizational Process Assets and Incorporated Lessons Learned
      - Shared sample project plans, improvements, etc., across the organization

The Second Wave – ML2 to ML3[2]

- **Addressed the three Organizational Process Areas early to provide a smoother transition to ML3 (con't)**
  - *Organizational Process Definition (OPD)* – Purpose: Establish and maintain a usable set of organizational process assets and work environment standards.
    - Developed EPO website, which is a repository for standard process manuals, SOPs, checklists, etc. The site also contains Tailoring criteria and other useful resources such as sample plans, etc., shared with the SSC-C organization by its projects
    - Built SSC-C Organizational Measurement Repository (OMR) for projects to use for managing their projects and capturing standardized cost, schedule, and process performance measurement data
      - Defined Balanced Scorecard measures directly related to CMMI® and Process Improvement

The Second Wave – ML2 to ML3[3]

- **Addressed the three Organizational Process Areas early to provide a smoother transition to ML3 (con't)**
  - *Organizational Training (OT)* - Purpose: Develop the skills and knowledge of people so they can perform their roles effectively and efficiently.
    - Identified the training needed by the organization
    - Obtained and provided training to address those needs
    - Established and maintained training capability
    - Established and maintained training records
    - Assessed training effectiveness
      - Objective evaluation of OT process performed by the Process and Product Quality Integrated Product Team (PPQA IPT)

The Second Wave – ML2 to ML3[4]

- SSC-C organization developed basic Tailoring Guidelines
- SSC-C Projects developed ML2-to-ML3 Action Plans
- Developed internal "self-assessment" process for measuring ongoing implementation of ML2 processes
- Continued enhancing ePlan Builder tool to create new plans (e.g., SEP/SEMP) that are ML3 compliant
- Updated/Improved existing plans
- Provided additional CMMI® Training
- Added Work Breakdown Structure Tool and Architecture Development Web-Based Training Course
- Continued to Measure and Communicate Progress
- Maintained Momentum and Commitment to Goals

Timeline 2005-2006

- **May – Dec 2005**
  - Updated Organizational processes with ML3 language
  - Built Organizational Measurement Repository (OMR) to track cost, schedule, and process performance measurement data
  - Developed Sample ML3 plans
  - Projects: Built ML2 to ML3 transition plans
    - Coaching and mentoring continued
- **2006**
  - Conducted project-level Maturity Level 3 SCAMPI℠ Class “A” appraisals
    - 6 Projects Appraised between June and December
    - 5 Achieved ML3
  - Projects worked to correct consistent weaknesses in Peer Reviews, Decision Analysis and Resolution (DAR), PPQA

Timeline 2007[1]

- **January 2007**
  - 1 additional project achieved ML3
  - Collected data from 30+ “non-focused” projects
    - Tailoring Guidelines
    - Project Management Plans
    - SEMP/SDPs
    - PPQA Plans
    - CM Plans
    - M&A Plans
- **February 2007**
  - Conducted 5-day Readiness Review
  - Collected additional artifacts needed

Timeline 2007[2]

- **April 2007**
  - Conducted Command-level ML3 SCAMPI℠ Class “A” appraisal – First SPAWAR Systems Center to achieve Command-level ML3
  - 9 Projects in appraisal scope – 7 Focused, 2 Non-Focused
    - >8000 artifacts submitted, 164 interviewees
  - SEI Senior Member was Lead Appraiser (Team Leader)
  - 2 other SEI Authorized Leads on the Team
  - 1 Government person from NSA
  - 1 Government person from SSC-C
  - 3 team members with multi-appraisal experience

Approved for public release; distribution is unlimited (15 OCT 2007)

Success Factors of Implementation[1]

- **Carefully select Initial Projects**
  - Start with interested projects
    - High Sponsor interest
    - Strong need/desire to improve

- **Set Guidelines (criteria) that yield benefits, for example, SSC-C's CMMI® Projects meet the following:**
  - Systems or software engineering effort
  - Funding directly with SSC-C
  - SSC-C performs the Project Management function
  - SSC-C PM is directly responsible for product delivery
  - Multi-year effort
  - Over $2M per year
  - Not limited to level of effort for services
  - Not merely a pass-through contract

Success Factors of Implementation[2]

- **Assign a CMMI® resource to each project**
  - – Strong facilitator with strong CMMI® knowledge
  - – Conduct regular (at least monthly) process-focused meetings to ensure steady progress
    - Include all key process area members (including contractors)
  - – Review project's plans, SOPs, work products
  - – Explain process area practices to the team's subject matter experts
    - Relates model to project
    - Helps team define typical work products
    - Helps team identify and collect direct and indirect evidence
  - – Conduct mini assessments to benchmark progress
  - – Share/provide organizational tools, templates

Success Factors of Implementation[3]

- **Project Team**
  - Project Manager - involved and committed to success
  - Document specialist/Technical Writer role for coordinating documentation, revisions
  - Active, skilled PPQA manager is a great benefit
    - Also can serve as the Measurement Analyst
  - Useful plans are built by the key players; shelfware is built by the novice or new contractor
  - Don’t let one person wear too many hats
    - Resource the team properly
  - New technology and complex systems are NOT necessary for success
- **A Customer that supports the initiative is a plus**

Success Factors of Implementation[4]

- **Recognize and Publicize Early Successes**
  - ‘Project-level’ SCAMPIs provided early successes due to conducting the appraisal using the “continuous representation” of the model
    - Scope of appraisal looked at all 7 ML2 PAs, then 11 ML3 PAs
    - If all the PAs were satisfied, then the project achieved ML2 and/or ML3 through equivalent staging
    - Or, Projects received Capability Level 2/3 for various PAs satisfied (e.g., CM, SAM, REQM, PP, PMC, TS, PI, DAR)
  - Led to BIG success! - SSC-C became the first SPAWAR Systems Center to achieve CMMI® Maturity Level 2 (April 2005)
  - Continued similar approach to Maturity Level 3
    - 1st Successful ML3 Program – July 2006
    - 4 more projects achieved ML3 in late 2006
  - Command CMMI® Maturity Level 3 – April, 2007
    - 1st SPAWAR Systems Center to achieve ML3

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Appraisal Planning/Execution

Measuring Progress

SEI Partner
Technical Software Services, Inc.

Appraisal Planning

- 7 SEI staff members were involved in the SSC-C Class “A” SCAMPIs
- Required early planning to get each SEI staff member’s commitment to appraisal dates
- Built detailed schedule for ML2 and ML3 project and organizational-level appraisals
- Obtained commitment from project team members concerning availability on appraisal dates
- Reserved conference and meeting rooms well in advance

Appraisal Execution[1]

- **Pre-Readiness Reviews (PRRs) helped to ensure projects were ready and the Formal RR would lead to 90%-100% coverage**
  - Used Appraisal tool to conduct PRRs
    - Provided early and easy access to the direct and indirect evidence for each process area's specific and generic practices
    - Provided means for communicating appraisal team comments
      - Used convention to denote status of each practice

        (e.g., PRR-SG: Direct OE satisfies practice OR

        PRR-SG: Direct and indirect OE is too old)
    - Provided early feedback to the projects
    - Provided easy upload of new artifacts supplied by projects

Appraisal Execution[2]

- **Formal RRs conducted on-site with Appraisal Team Members (ATMs)**
  - SEI Lead Appraiser and ATMs worked as a team
  - Used Appraisal tool to conduct RR
    - Provided easy access to the direct and indirect evidence for each process area's specific and generic practices
    - Provided means for communicating appraisal team comments
      - Used convention to denote status of each practice

        (e.g. RR-CS: Direct OE indicates performance of practice OR RR-CS: Direct and indirect OE is too old)
    - Provided good feedback to the projects on items still missing
    - Provided easy upload of new artifacts supplied by projects

Appraisal Execution[3]

- **SCAMPI℠ Class A appraisals conducted on-site**
  - Involved mostly the "Interview" process since RR ensured direct and indirect coverage was evident
  - Used Appraisal tool to conduct SCAMPI℠
    - Affirmation section of tool allowed for easy update following each interview
    - Tool allowed primary team member to select practice compliance and secondary member to concur (or not)
    - Authorized lead appraiser (team lead) then verified each practice within the process area
    - Built-in color coding provided easy visibility to "weaknesses"
    - Facilitated voting process at Goal level and Process Area
  - Each project-level ML3 SCAMPI℠ conducted in 5 days and Command-level ML3 SCAMPI℠ conducted in 10 days

Lessons Learned

Implementation

Appraisals

Lessons Learned - Implementation

- **Senior Management support is critical to success**
- **Training**
  - Everyone needs to be engaged – "train the masses"
  - Specific training for process owners/subject matter experts
- **Utilize Teams (IPTs) as champions of specific processes**
  - Multi-department representation
  - Change agent mentality
  - Process-focused charters
- **Resource Properly**
  - Implement with projects that want to improve, can benefit from efforts, and that recognize own weaknesses
  - EPO staff provided skilled coaching, resources, support, and tools
  - Project members learned by doing and maintaining
- **Goals and Publicity**
  - Keep goals to sizable bites (projects)
  - Publicize successes; Share best practices

Lessons Learned – Appraisals[1]

- Provide CMMI® mentoring and coaching for projects selected for an appraisal

- Build detailed schedules for appraisals early in planning phase to use as a roadmap

- Plan early in order to obtain project team member and appraisal team member commitment to appraisal dates

Lessons Learned – Appraisals²

- Invest in an Appraisal Tool to facilitate easy collection and evaluation of appraisal data

- Perform a Pre-Readiness Review to ensure minimal coverage gaps are identified at the formal Readiness Review

- Conduct individual project appraisals to ensure successful organizational appraisals

- Document Lessons Learned from conducting appraisals to improve the appraisal process

What has success meant?

Systems Center Charleston

- **Business Results**
  - SCN: “They see us as a model and want to increase our efforts.”
  - Automation Program: “We had hundreds of sites and there was a need for a structured organization to put a ‘wrapper’ around that and control it. CMMI became the wrapper.”
  - CICS: “CMMI was key to achieving the project goal.”
  - VIDS: “The VIDS failure (2000) motivated implementing CMMI because the team needed to change course or the customer would have no confidence in system development. It was a tremendous success…”
- **Others Asking for Help**
  - PMS 408 – CREW program
  - SESG / NAVAIR / NAVSEA
  - Marine Corp – Quantico
  - Air Armament Center, Eglin AFB

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Beyond Maturity Level 3

Plan of Action for ML4/5

Technical Software Services, Inc.

Continue Momentum

- **No more "Ratings for Life"**
  - – Ratings are now valid for only 3 years (April 2007- April 2010)
  - – SSC-C will lose its CMMI® ML3 rating on 27 April 2010 if another Command-level SCAMPI℠ Class "A" appraisal is not successfully completed before then
    - Sustain the current Command-sponsored projects (representative sample)
    - Self-Assessments/Appraisals – mentoring and coaching of more projects
- **Plan for and Implement**
  - – CMMI® V1.2 (CMMI®–DEV) New Model
  - – Maturity Levels 4/5

Plan of Action for ML4/5[1]

- **Take a fresh look at the entire measurement program with an eye towards managing the projects using quantitative data**
- **Collect and evaluate project historical data for measuring cost, schedule, and quality**
- **Establish a process for maintaining the appropriate data to begin managing quantitatively**
  - Select at least one "main contributor" sub process per project lifecycle phase, at least one project management sub process and at least one support sub process
- **Statistically manage the data**
  - Using statistical methods (e.g., Statistical Process Control charts, histograms, trend charts, etc.)

Plan of Action for ML4/5[2]

- **Demonstrate stable historical data for measuring cost, schedule, and quality**
  - Stable data will help you answer questions like:
    - Can you predict where your next data point will fall?
    - Do you know what your baseline is for cost/schedule performance?
    - Is your product quality what you expect it to be?
    - Are you finding “enough” defects before the customer gets the product?
  - As a guideline, strive for at least 4 consecutive data points within your established control limits

Plan of Action for ML4/5[3]

- **Formalize performance baselines for the project and provide baseline data to organization**
- **Re-establish quantitative objectives (for example):**
  – Reduce cost variance to +/- 5%
  – Reduce schedule variance to +/- 10%
  – Reduce delivered defects by +/- 10%
  – Improve major saves found in peer reviews by 20%
- **Use baselines and variance to predict future performance**
- ***Keep up the ML2 and ML3 process performance!***

Timeline 2007[1]

- **May – Dec 2007**
  - – Developed Process Improvement Plan for ML4/5
  - – Developed Detailed Schedule for ML4/5
  - – Developed QPM Plan Template
  - – Held various ML4 Meetings with projects
  - – Held SCAMPI℠ for one project using CMMI® v1.2
    - September: Project achieved ML3
  - – Increase usage of tools across departments/projects
  - – Add additional plans to ePlan Builder as needed
  - – Continue internal CMMI® Level 3 mini assessments

Begin Maturity Level 4/5 implementation

Timeline 2007²

- **May – Dec 2007 con't**
  - Enhance/Expand OMR
    - More Quality Data from Peer Reviews, Testing Phase and Defects from Production
    - More Statistical Process Control (SPC) Charts
  - Command and Department Project Reviews process
    - Look at quality of plans and implementation of best practices
    - Reviews of project status by management driven by project metrics
    - More Peer Reviews to measure "saves"
  - Better tailoring guidance for smaller projects

Begin Maturity Level 4/5 implementation

Timeline 2008-2010

- **2008**
  - – Conduct ML3 SCAMPI℠ Class “A” appraisals for new projects
  - – Conduct ML4/5 SCAMPI℠ Class “A” appraisal for one program
- **2009**
  - – Conduct ML3 SCAMPI℠ Class “A” appraisals on other Command projects
  - – Conduct ML4/5 SCAMPI℠ Class “A” appraisals on other Command projects
- **2010**
  - – Conduct SSC-C Command-level ML4 SCAMPI℠ Class “A” appraisal in April 2010

Summary

- Decided on Approach – Use CMMI® for Process Improvement and Measuring Progress
- Using extensive research, determined the 'Critical Success Factors' for Implementing CMMI®
- Built Plan of Action/Detailed Schedule for Appraisals
- Provided Training – Systems Engineering, Processes, & CMMI®
- Advertised Early Successes
- Implemented Plan Successfully for Phase 1 – CMMI® Maturity Level 2 and Phase 2 – CMMI® Maturity Level 3
  - On schedule, on budget
- Laying groundwork for higher maturity

Any Questions?

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Achieving Agility in Cyberspace

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

Philip Boxer, Ed Morris,
Bill Anderson (presenter)

24th October 2007

What is Cyberspace?

Cyberspace* is a term used to define the virtual world, built entirely of computers, computer networks, and associated systems around the globe

"*Although Cyberspace would not exist without physics, it is by no means bounded to the pure physical reality term.*"

Wertheim, M., *De hemelpoort van cyberspace,* Anthos, Amsterdam, 2000.

**The term was coined by William Gibson in his novel Neuromancer*

Cyberspace as a Theater of Engagement

Loss of boundaries

- A threat can arise instantaneously anywhere. (SIPRNet is not immune.)

Fluidity of the environment

- No consistent front or mode of attack

No global visibility

- Large, chaotic, opaque motives, masking identity is easy

Uncertain nature of time

- Not necessarily a relation between the time an attack occurs and the time it was launched

Overlapping and shared jurisdiction

- Involves many parties, many areas have no clear dominion, spillover across jurisdictions is the norm

What are the Military Threats in Cyberspace?*

Limited cyber war: Information infrastructure is the means and target of attack (i.e., low-intensity conflict)

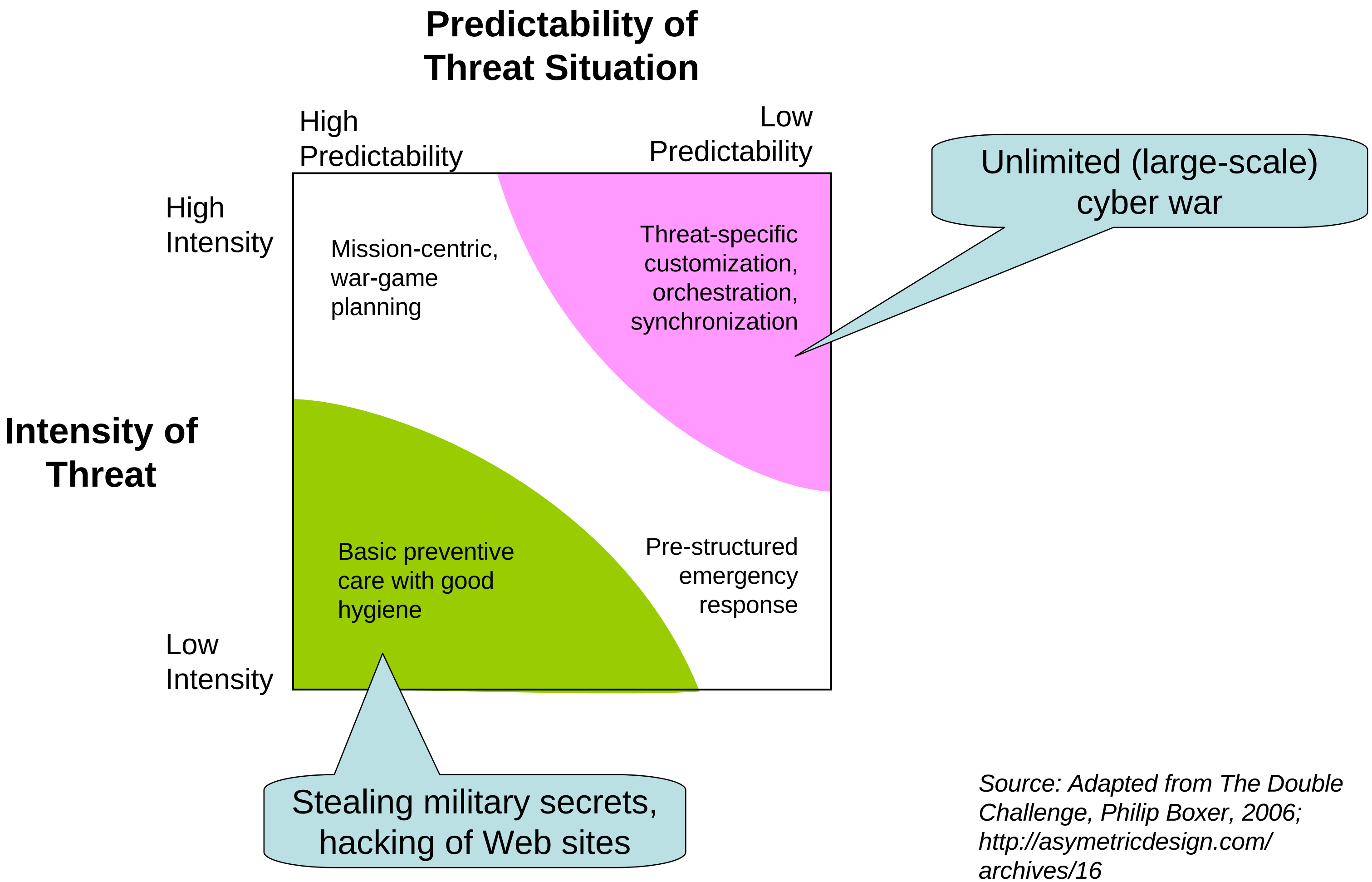
- e.g., denial of service attacks using botnets against Estonia in Spring, 2007

Unlimited cyber war: Comprehensive in scope and target coverage (i.e., high intensity conflict)

- no distinctions between military and civilian targets or between the home front and the fighting front.
- physical consequences and casualties
  - attacks deliberately intended to create mayhem and destruction
- economic and social impact—in addition to the loss of life—could be profound

NATO Review, Vol 49, No 4, Winter 2001

Framing the Cyberspace Theater



Source: Adapted from The Double Challenge, Philip Boxer, 2006; http://asymetricdesign.com/archives/16

Low-Intensity, High-Predictability Threats

Adversaries threaten (and present opportunities) consistent with plans

- Goal is to develop tactics that counter these predictable threats.
- For the most part, these threats can be addressed by *good hygiene*, such as
  - installing security patches and procedures in a timely way
  - verifying compliance
  - managing passwords and other data securely
  - monitoring attempts to access systems
  - gathering data about the attackers and turning attackers' actions against them

Low-Intensity, Low-Predictability Threats

Adversaries place unanticipated demands on the organization:

- Malicious agent employs a novel strategy, exploits a new flaw, or targets a new victim.
- Some form of *emergency response* is required.

Activities supporting this function include:

- coordinating the response to counter the threat
- monitoring the frequency/type of events managed by the emergency response capability
- identifying the chain of culpability, where possible
- analyzing patterns of activity in order to understand targets, motivations, strategy, and tactics

High-Intensity, High-Predictability Threats

Adversaries use high-intensity but predictable attacks to achieve large-scale geopolitical or economic gain.

Key to success is to *war-game*—to coordinate relationships with identified partners to meet anticipated threats

To prepare for these threats

- develop scenarios that reflect likely forms of attack
- identify external partners that will be involved and establish coordinated plans for responsibilities
- train personnel on available tools and technologies
- experiment with tools and tactics
- allow sufficient flexibility to allow personnel to adapt to minor variations of known situations

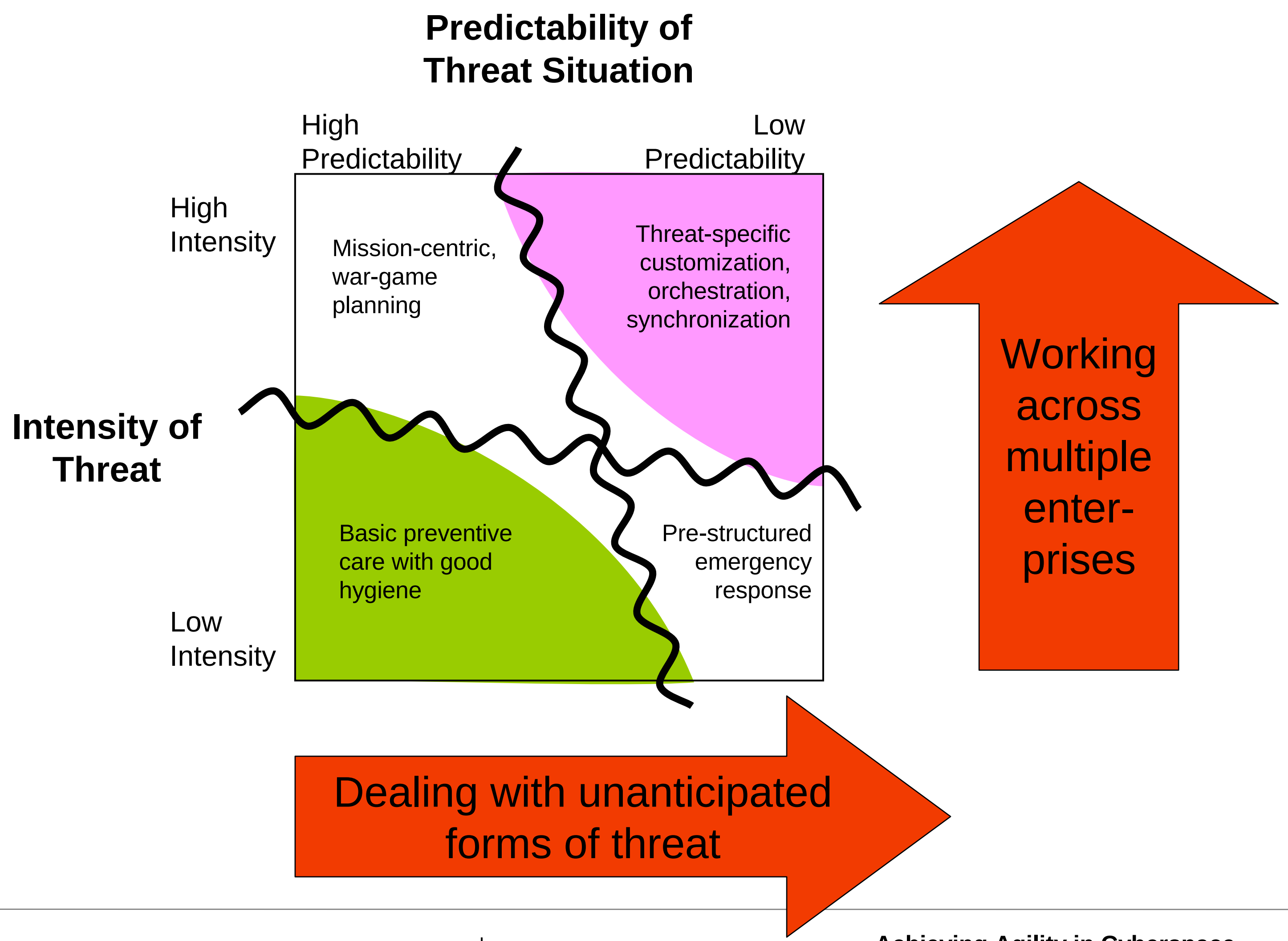
High-Intensity, Low-Predictability Threats

High-intensity and low-predictability conflict implies

- The good hygiene approach (bottom left quadrant) is not sufficient to meet the demand of a rapidly changing threat.
- Emergency response teams (bottom right quadrant) will become overwhelmed as the intensity of the conflict and the stakes involved increase.
- War-gamed responses (top left quadrant) are unlikely to map beyond the opening salvo because the intelligent adversary will continually adapt to the response.

No matter how good the hygiene, emergency response, and war-gaming, intelligent adversaries can drive the situation into the top right quadrant whenever they choose.

The Cyberspace Theater's Double Challenge



Forms of Agility Required

Type II Agility

Anticipate the demands on the mission and how products or services will be used

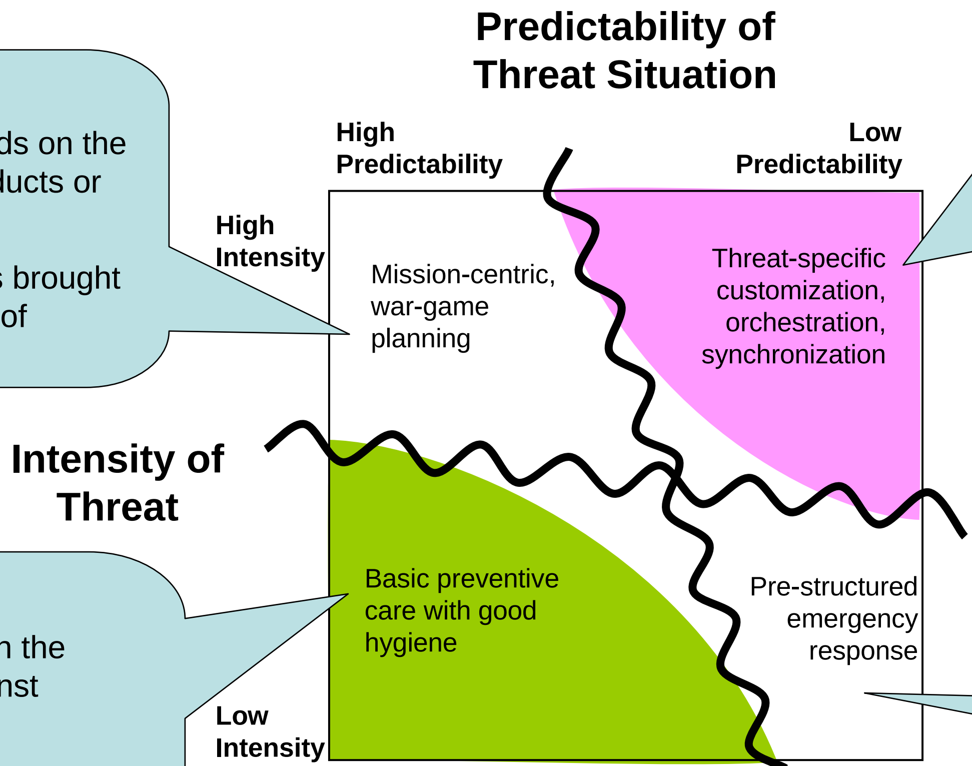
Multiple organizations brought under a unified chain of command

Type III Agility

Can't anticipate the demands on the mission

Can't anticipate how products or services will be used

Multiple organizations each with its own chain of command



Type I Agility

Anticipate the demands on the mission of defending against intrusion

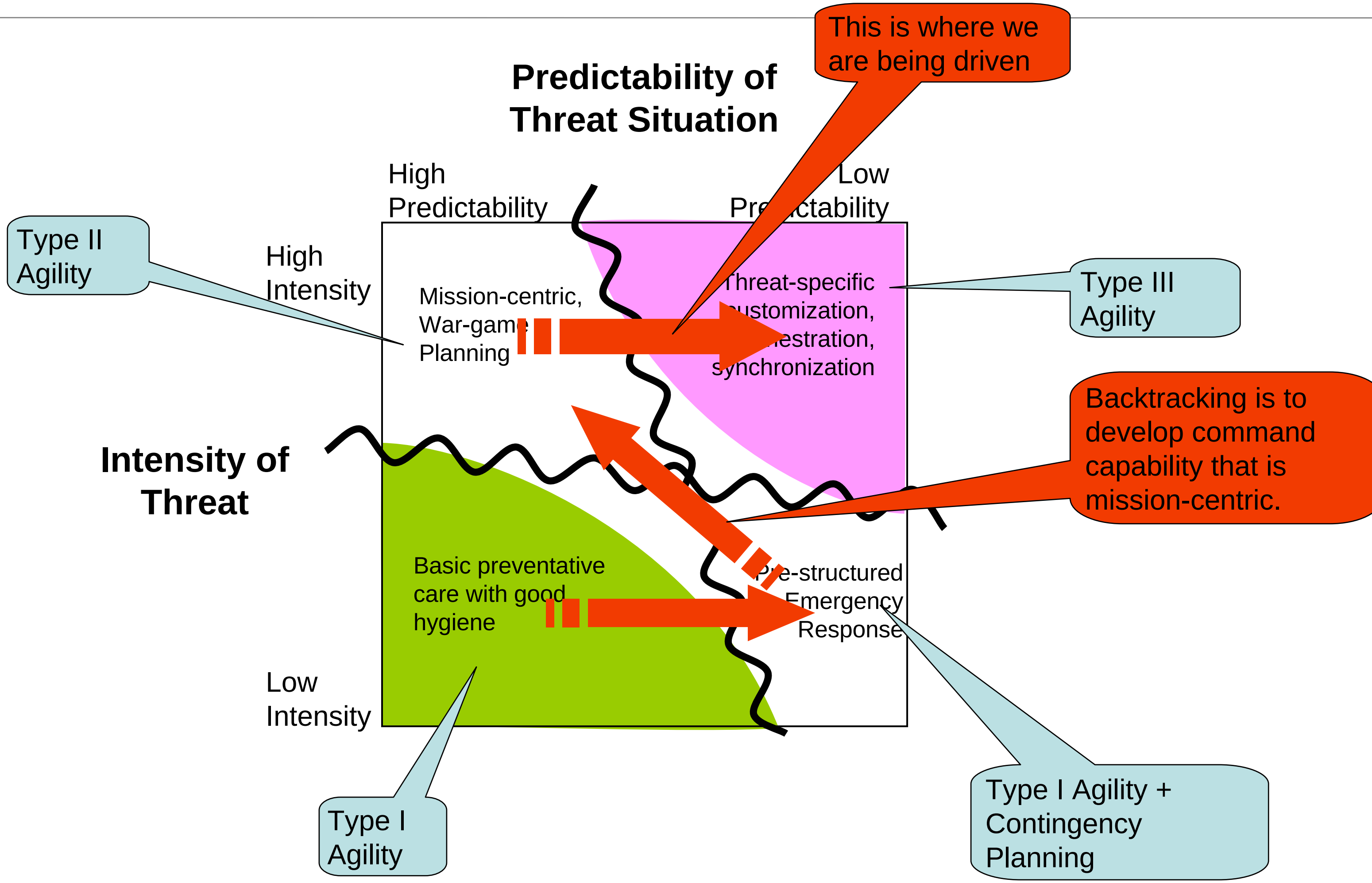
Anticipate how products or services will be used

Ensure that managerial entities apply appropriate commands

Type I Agility + Contingency Planning

Source: The Three Agilities, Philip Boxer & Richard Veryard, 2006; http://asymetricdesign.com/archives/18

An Unfortunate Trend



How Does Agility Relate to Command?

Agility Type	Command Governance
Type I ▪ within the enterprise ▪ to predicted threats	**Stretching resources** across the organisation to optimally meet demands (i.e., cost efficiency). **Ensuring** that rules are followed
Type II ▪ across enterprises ▪ to predicted threats	**Leveraging existing** infrastructure and capabilities to address threats **Acting intelligently** by capturing and driving key information and knowledge through the organization **Co-ordinating relationships and processes** between multiple players (i.e., flexibility).
Type III ▪ across enterprises ▪ to unpredictable threats	**Harmonizing competing priorities, multiple strategies, and technologies** across organizations **Sensing and responding across organizations** to new threats and opportunities **Shift** command authority **to the edge**

Distinguishing Forms of Command

The nature of the managerial control is*

- **Directed**
  - Command that can be controlled by a central authority
- **Directed Collaboration**
  - Command that requires collaboration to fulfill an agreed-upon central purpose
- **Distributed Collaboration**
  - Command where there is no centrally agreed-upon purpose (The purpose must be built in response to situations.)

* *"Architecting Principles for Systems of Systems," Mark W. Maier.* http://www.infoed.com/open/papers/systems.htm

Mapping Command Types to Agility Types

Demands/ Purposes

Autonomous Command Entities	Anticipated	Unanticipated
Multiple	Directed Collaboration (Type II Agility)	Distributed Collaboration (Type III Agility)
Single	Directed Composition (Type I Agility)	Directed Composition (Type I Agility + Contingency Plan'g)

Distributed Collaboration, Type III Agility Requires Edge-Synchronization

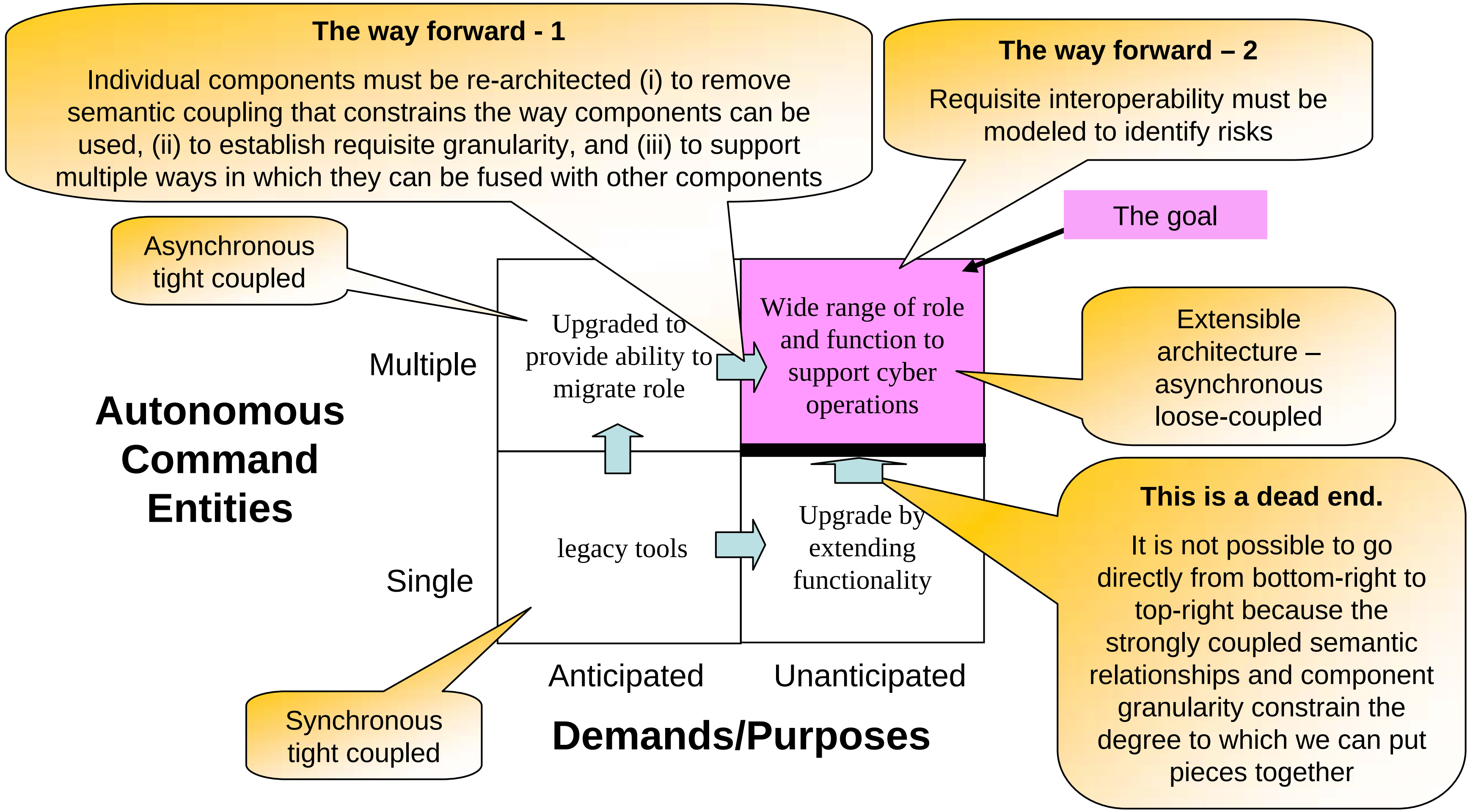
This means

- Missions are defined at the edge where the threat is encountered, rather than at the center.
- The infrastructures have to be “loosely-coupled” and “under-constrained” (i.e., able to be orchestrated and composed at the edge).

This in turn requires us to develop

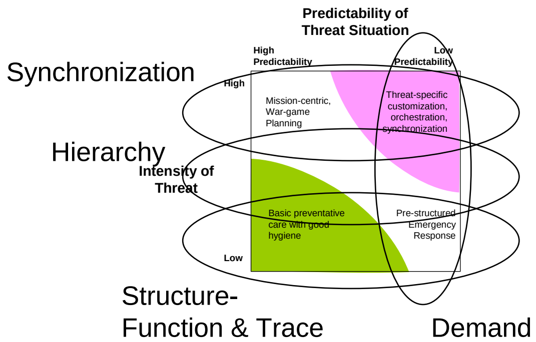
- command structures that support power-to-the-edge, and
- agile infrastructures—with stratified granularity—that are sufficiently expressive to enable power-at-the-edge.

How do we get there?



Model Interoperability Through the Command Structures and infrastructures in Their Contexts-of-Use

Model interoperability with 5 layers of analysis:



- **Structure/Function**: The physical structure and functioning of resources and capabilities.
- **Trace**: The digital processes and systems that interact with the physical processes.
- **Hierarchy**: The formal hierarchies under which the uses made of both the physical and the digital are held accountable.
- **Synchronization**: The lateral relations of synchronization and orchestration within and between the organizations providing services "on the ground"
- **Demand**: The nature of the contexts-of-use giving rise to demands on the way the operations are organized to deliver services effectively and timely.

These 5 layers combine to form a model of the operational space as a whole, enabling Cyber Command to analyse the threats associated with orchestrating and synchronizing systems of systems in relation to particular forms of demand.

For More Information

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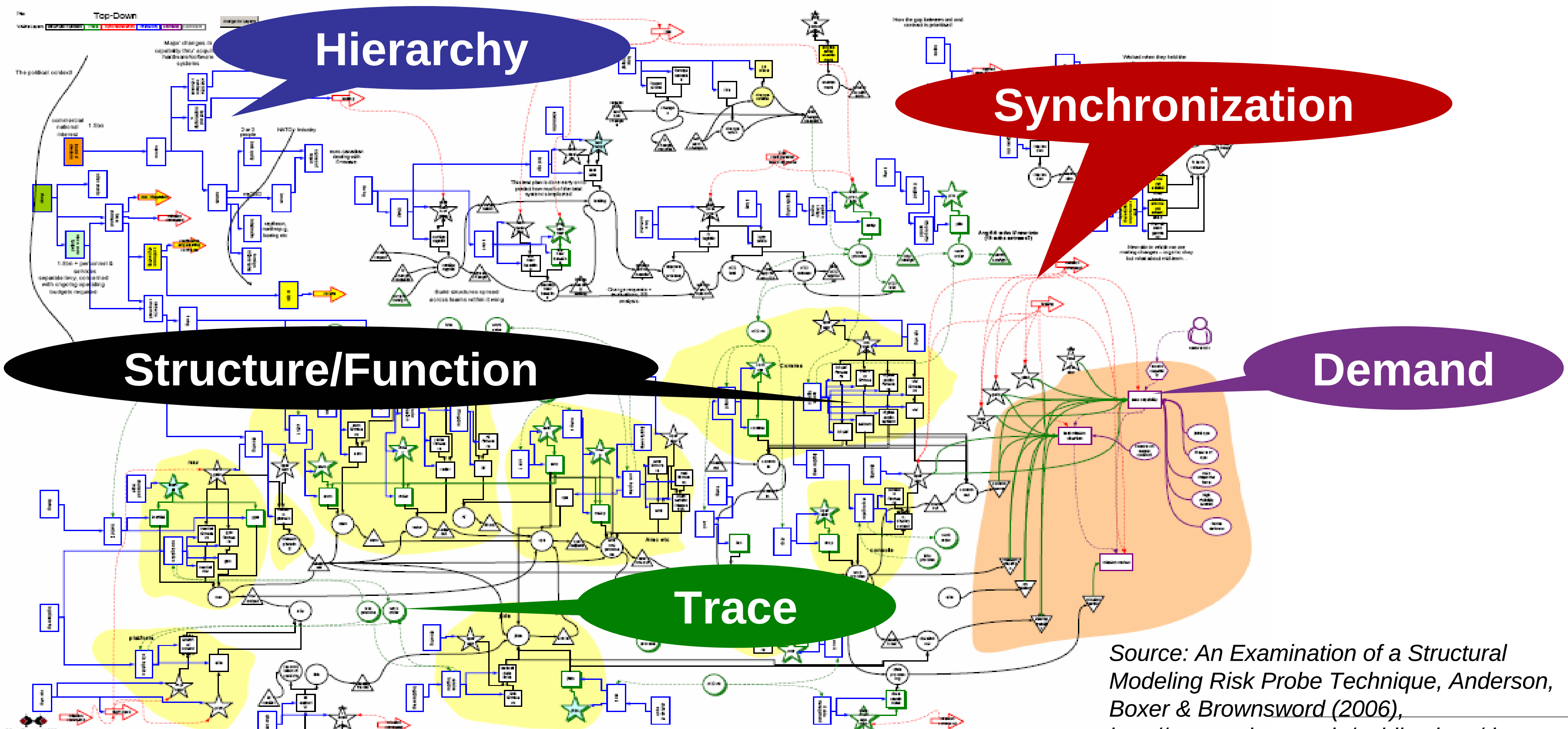
Software Engineering Institute | Carnegie Mellon

Visual PAN—Rapid, Well Structured, Spaghetti

The PAN symbols and their relationship rules generate five interlocking layers in the visual model.

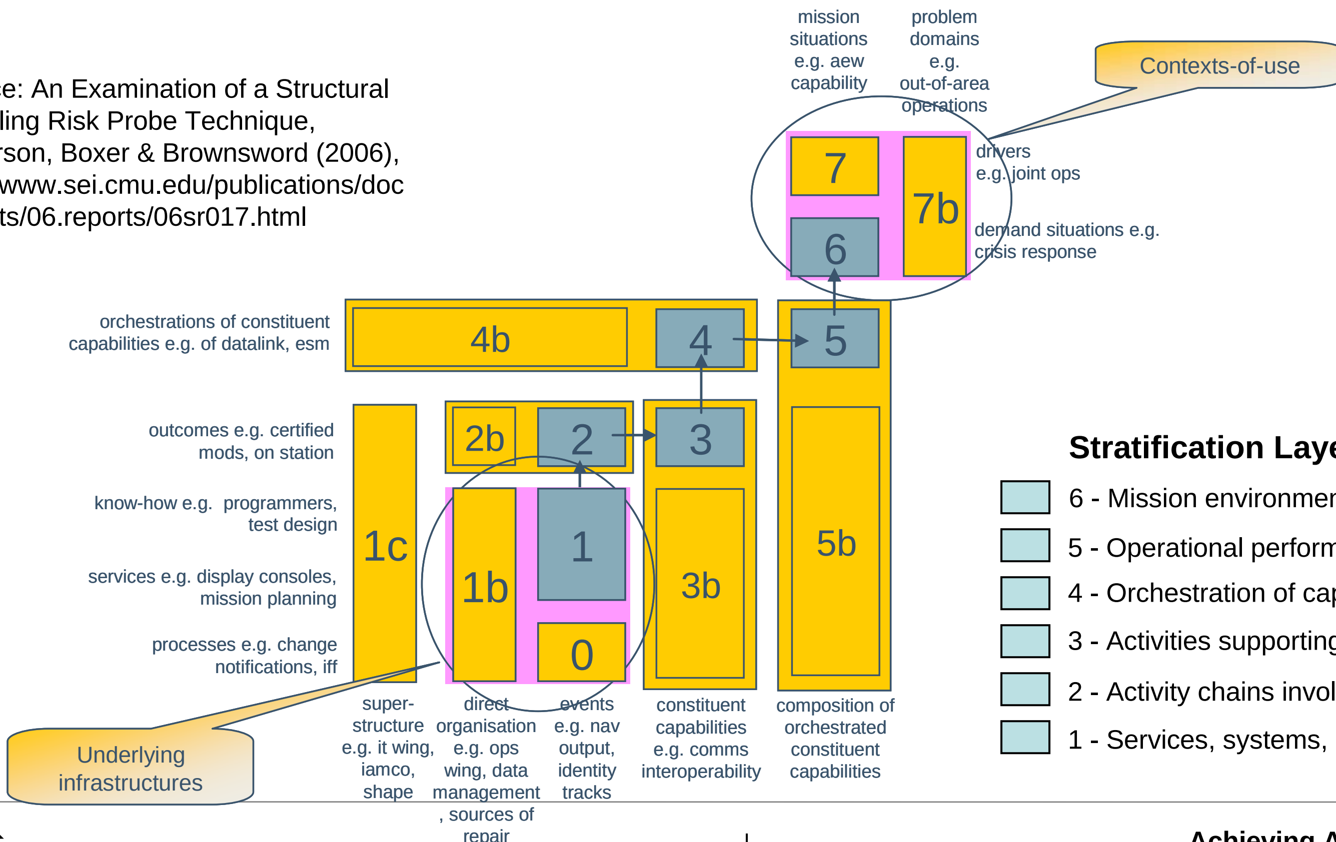


Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

Stratification Brings Structure to the Spaghetti

A six-layer stratification forms a framework against which the people, processes, and technical structures are analyzed in relation to the demands being placed upon them.

Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

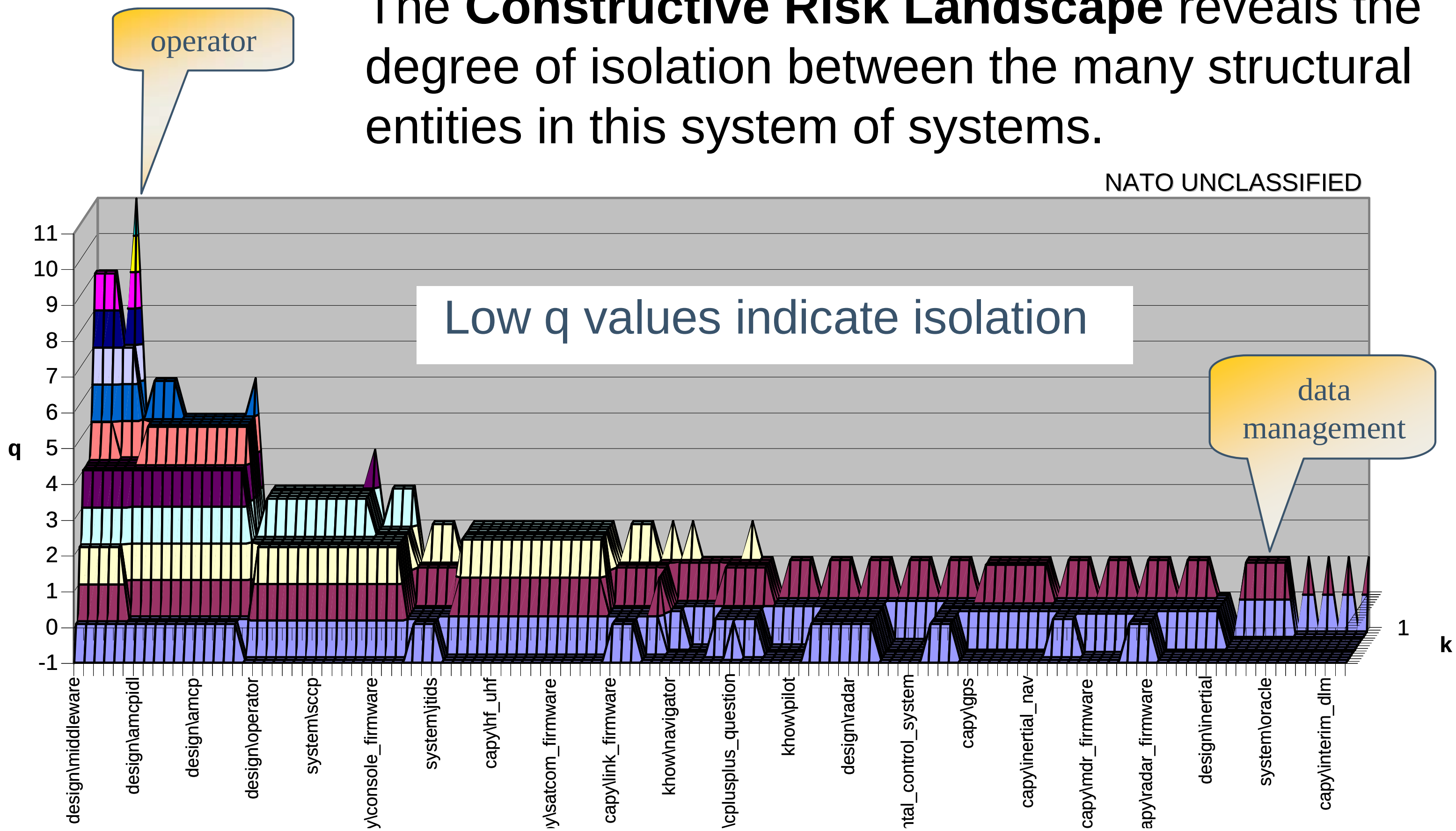


Stratification Layers

- 6 - Mission environments
- 5 - Operational performance of the capability
- 4 - Orchestration of capabilities by crew and operators
- 3 - Activities supporting the operational capability
- 2 - Activity chains involved in integrating components
- 1 - Services, systems, and know-how

Type 0 - Constructive Risk Landscape

The **Constructive Risk Landscape** reveals the degree of isolation between the many structural entities in this system of systems.



q = number of events related to service

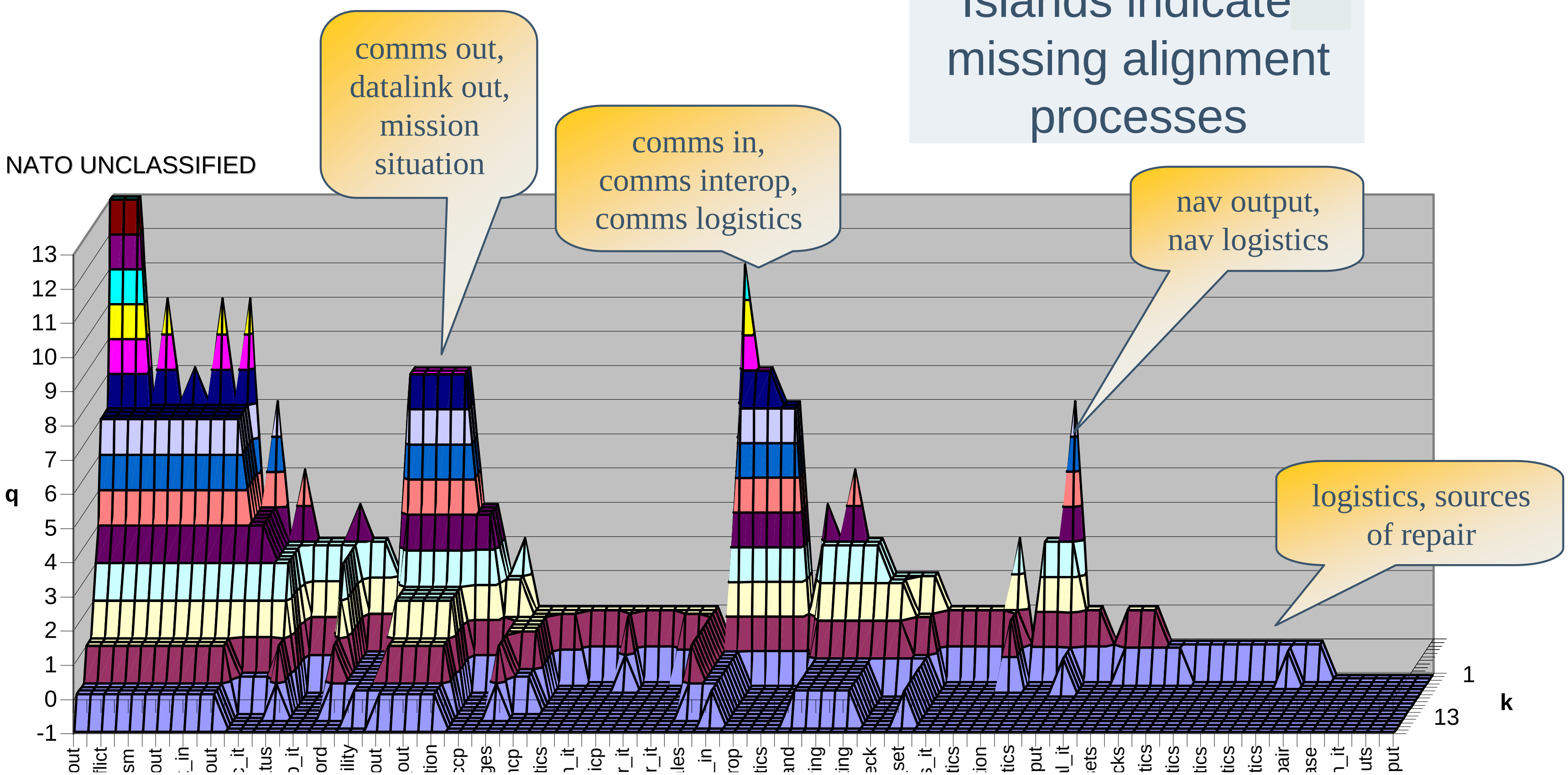
k = number of other services with common events at this level of q

Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006). http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

Type I - Customization Risk Landscape

The **Customization Landscape** reveals islands of high connectivity with broad regions of separation.

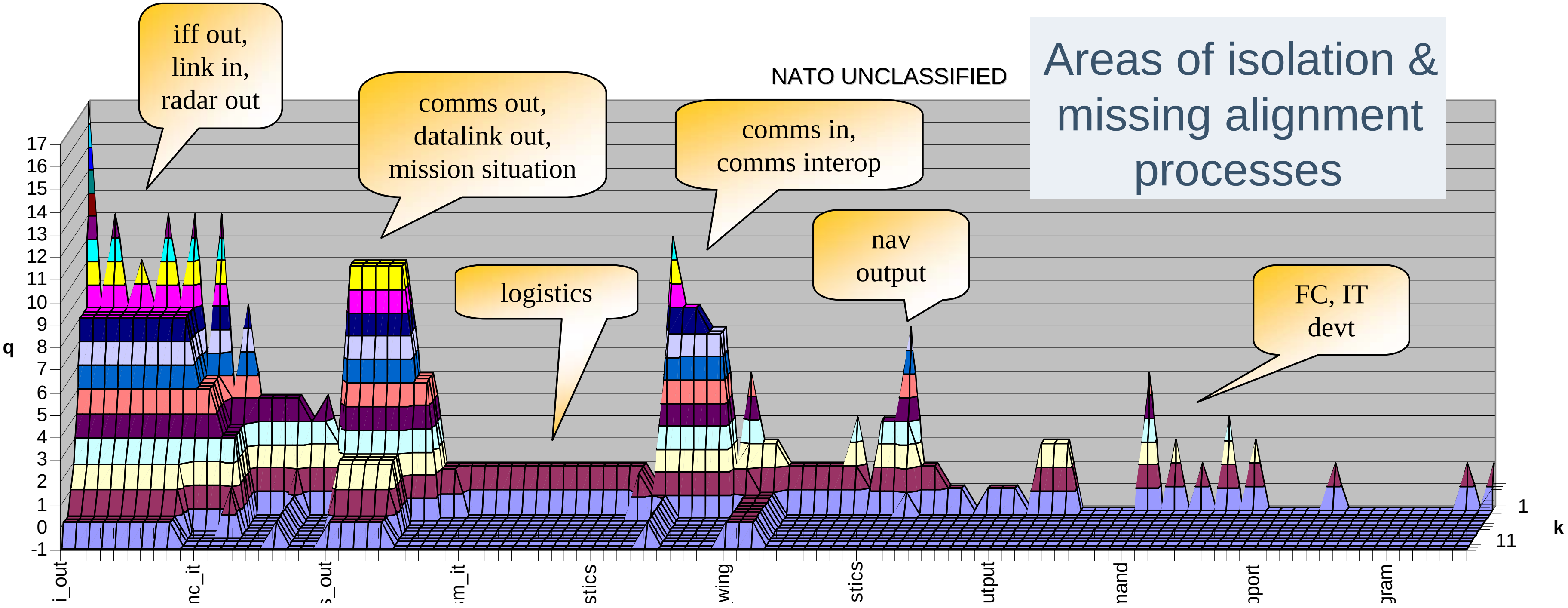
Islands indicate missing alignment processes



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006). http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

Type II - Orchestration Risk Landscape

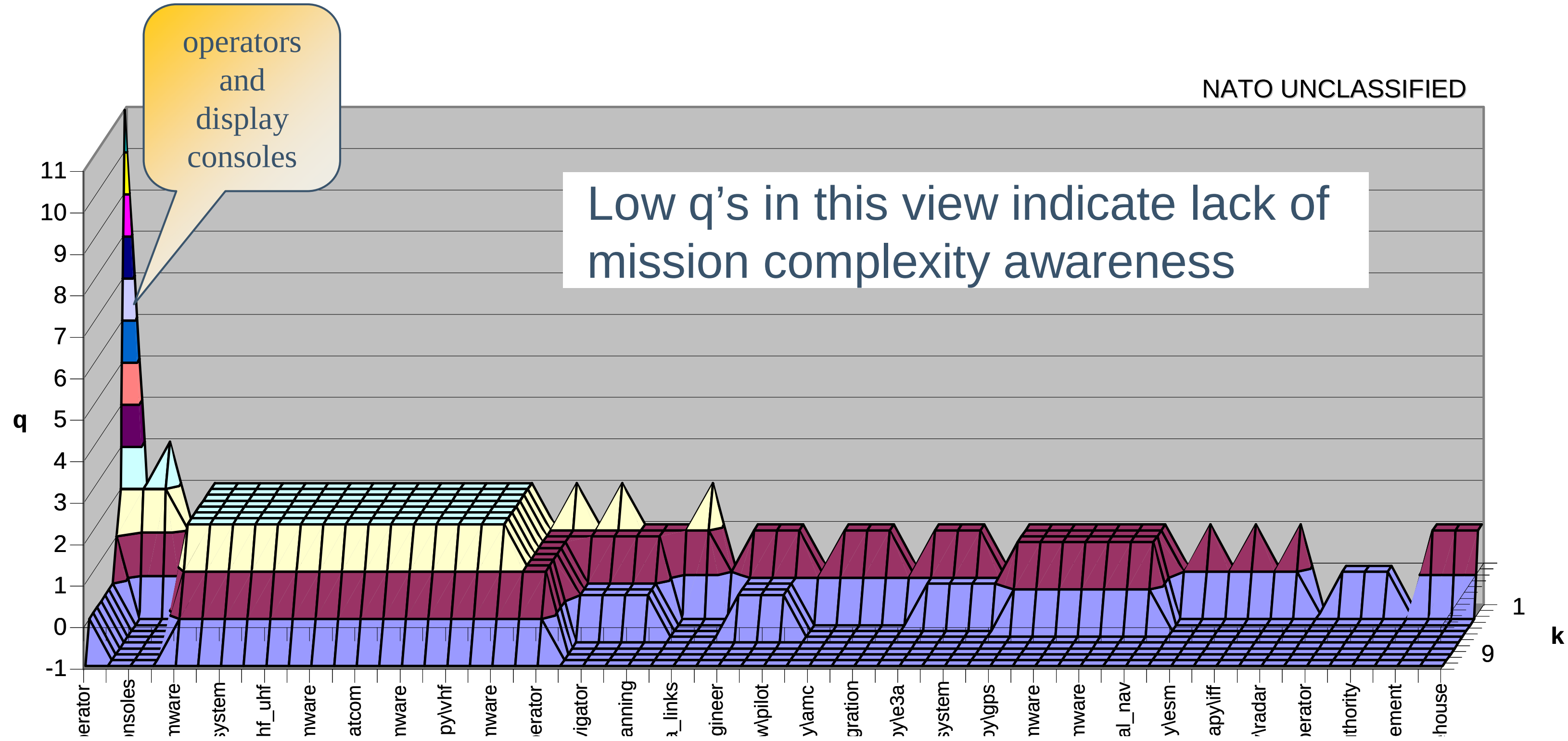
The **Orchestration Landscape** reveals areas of isolation, islands of high connectivity, and broad regions of separation.



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

Type III - Synchronization Risk Landscape

The **Synchronization Landscape** shows that the predominant mission awareness integration point is the system operator and the operator's display console.



Source: An Examination of a Structural Modeling Risk Probe Technique, Anderson, Boxer & Brownsword (2006), http://www.sei.cmu.edu/publications/documents/06.reports/06sr017.html

Requirements-Driven and Partnership-Based

Systems Engineering & Training Education

Jerrell Stracener
Stephen Szygenda
James Rodenkirch

October 24, 2007

Agenda

- Systems Engineering Education
  - SMU (Systems Engineering Program) Overview
  - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary

Definitions

- Education
  - “can be thought of as the process of acquiring knowledge and information, usually in a formal manner… [including] learning how to think”
  - “typically measured by testing comprehension and knowledge retention”
- Training
  - “the process of gaining proficiency in some skill or skill set”
  - “usually measured by the learner’s ability to demonstrate the learned skill by producing desired outcomes”

Definitions from the American Society of Quality, Certified Quality Manager Handbook

Agenda

- Systems Engineering Education
    - SMU (Systems Engineering Program) Overview
    - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary

Objective (of this section)

To present the highlights of a non-traditional university systems engineering program that was initiated and has been developed

– in response to aerospace & defense needs

– with extensive industry and government participation

– with DoD OSD / DAU / Military Services review & guidance

Systems Engineering Program (SEP) Overview

Mission

- Provide education relevant to the engineering of systems
- Foster and conduct research in selected areas of systems engineering
- Maintain a Systems Engineering Program in partnership with industry, government and associations that is responsive to current and emerging needs and requirements

Driven by Industry and Government needs

Systems Engineering
- Education
- Research

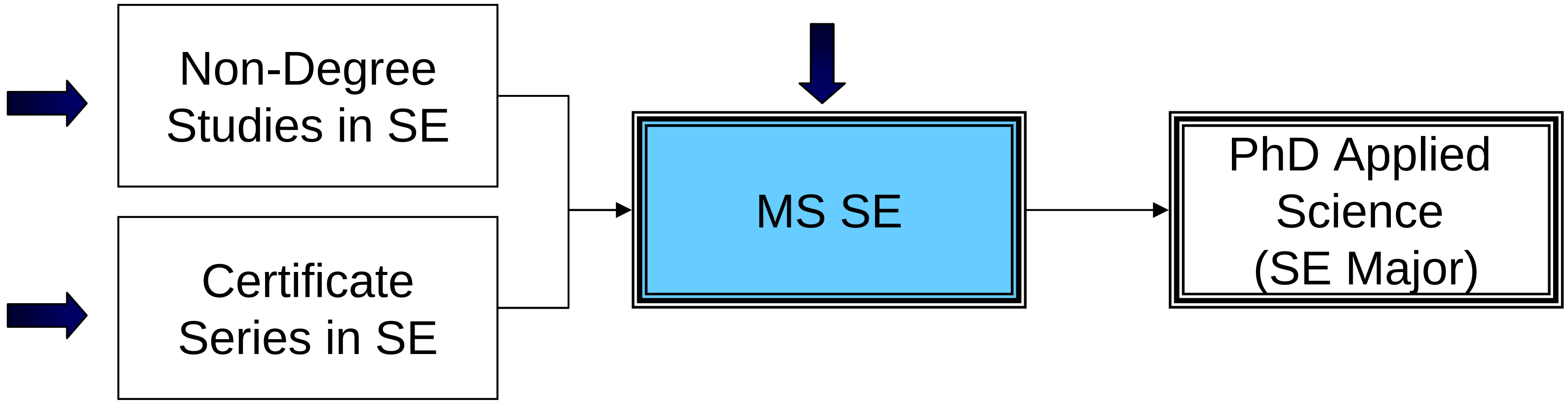
<u>Engineers, Designers, Analysts</u>
- Systems Thinking Skills
- Problem definition, solving, and presentation skills

<u>Systems Engineers</u>
- Entry level skills
- Skills update
- Career growth

<u>Team Leaders</u>
- Skills update
- Systems Thinking Skills
- Systems Engineering Skills

To help you become a better engineer and manager

Current Academic Program



Academic Programs

- On-Campus and Distance Programs
  - MS SE
  - Fast Track Second Masters
  - Certificate Series in SE
  - Non-Degree Studies (for credit) in SE
  - PhD in Applied Science (Major in Systems Engineering)
- On-Site and Virtual On-Site Programs
  - MS SE
  - Fast Track Second Masters Program

MS SE Program Options

- “Live” on-campus and Distance Students via DVD
  - Very flexible structure
- On-Site and Virtual On-Site
  - Offered “live” only
  - Very little flexibility

MS SE Degree Requirements

- Thirty term-credit hours of graduate courses with a minimum GPA of 3.00 on a 4.00 scale.
- Satisfactory completion of the following five core courses:

EMIS 7300	Systems Analysis Methods
EMIS 7301	Systems Engineering Process
EMIS 7303	Integrated Risk Management
EMIS 7305	Systems Reliability, Supportability & Availability Analysis
EMIS 7307	Systems Integration and Test

MS SE Degree Requirements

- Satisfactory completion of one of the following tracks:
  - Systems Engineering Technology Track
  - Systems Engineering and Design Track
  - Logistics and Supply Chain Management Track
  - Systems Engineering Application Track
  - On-site (Executive Format) Track

MS SE Degree Admission Requirements

- MS SE Admission Requirements
  - Bachelor of Science in engineering*, mathematics, or one of the quantitative sciences (*a Bachelor of Science in an appropriate engineering discipline is required for the Systems Engineering and Design track)
  - G.P.A. of at least 3.00 out of 4.00 scale in previous undergraduate and graduate study.
  - A minimum of two years of college-level mathematics, including at least one year of calculus.

Current Systems Engineering Courses

Course Number		Title	Date Approved
EMIS	7300	Systems Analysis Methods	April-2000
EMIS	7301	Systems Engineering Process	September-1994
EMIS	7303	Integrated Risk Management	September-1994
EMIS	7305	Systems Reliability, Supportability and Availability Analysis	Sept 1994/Rev Apr 2005
EMIS	7307	Systems Integration and Test	September-1994
EMIS	7310	Systems Engineering Design	April-2000
EMIS	7312	Software Systems Engineering	April-2000
EMIS	7315	Systems Architecture Development	April-2000
EMIS	7320	Systems Engineering Leadership	Apr 2000/Rev Apr 2005
EMIS	7330	Systems Reliability Engineering	April-2000
EMIS	7335	Human-Systems Integration	April-2005
EMIS	7340	Logistics Systems Engineering	April-2000
EMIS	7347	Critical Infrastructure Protection/Security Systems Engineering	April-2005
EMIS	8340	Systems Engineering Software Tools	April-2005
EMIS	8342	Six Sigma Systems Engineering	April-2005
EMIS	8348	Supply Chain Systems Engineering	April-2005

Current Systems Engineering Courses

Course Number		Title	Date Approved
EMIS	7318	Systems Engineering Planning and Management	March-2007
EMIS	8305	Systems Life Cost & Affordability Analysis	March-2007
EMIS	8307	Systems Test and Evaluation	March-2007
EMIS	8310	Collective Systems Design	March-2007
EMIS	8315	Innovation Systems Design	March-2007

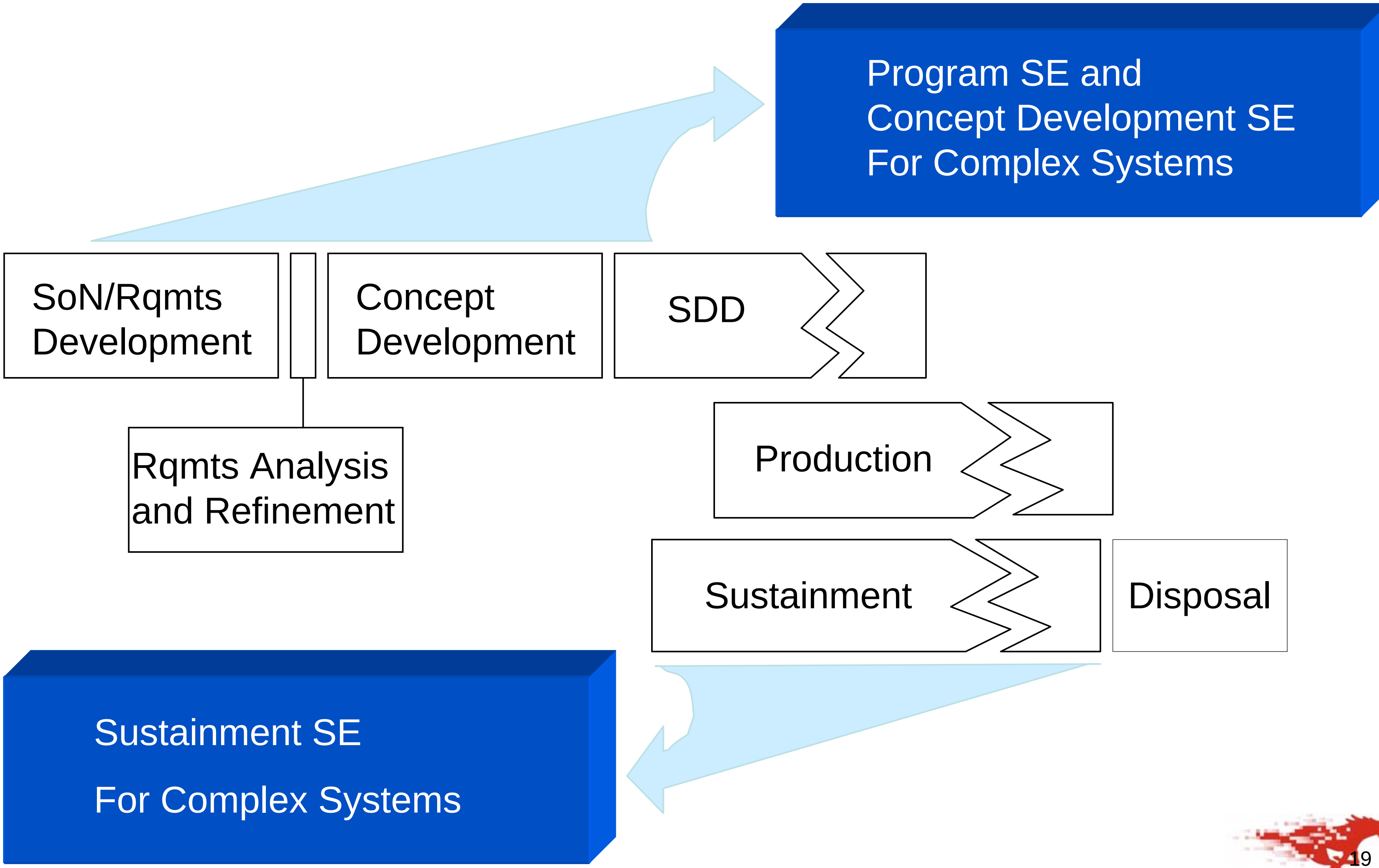
In-Development Courses

- Introduction to Systems Engineering (Undergraduate Course)
- Systems Requirements Engineering
- Acquisition Logistics Systems Engineering
- Sustainment Logistics Systems Engineering

Systems Engineering Course Development Process

SEP DT Identify Needs → Identify & Select Industry Subject Matter Expert → Subject Matter Expert Develops Course Proposal → Course Proposal Reviewed by DT Experts → Submit Course Proposal to EMIS Department Chair → Course Proposal Reviewed by EMIS Dept. Faculty → Course Proposal Submitted to SoE Faculty for Approval → Course Developed by Subject Matter Expert w/ Assistance by DT Experts

SMU Systems Engineering Research Focus



Funded Research

Funded by	Title	Dates	Amount
U.S. DoD DAU / NAVYSPAWAR	System Engineering in Science and Technology	October 1, 2007 – September 31, 2008	$40.000
Lockheed Martin Aeronautics Co.	Development of Response Framework to Regional Systems Engineering Education, Research and Training Needs	August 10, 2007 December 15, 2007	$40,000
U.S. Army- ISEC	Phase I: Re-engineering Not-for-profit Technical Organizations for Transition to Market-Driven Enterprises: Strategies, Models, and Application to the Technical Information Center	September 15, 2005- September 20, 2006	$89,488
Lockheed Martin Missiles & Fire Control	Potential Capability Maturity Model, Integrated™ (CMMI) Generic, Practice (GP) and Specific Practice (SP) Tailoring Approaches	September 15, 2005- May 31, 2006	$50,000
U. S. Navy-SPAWAR	Phase II: CIP Systems Engineering for Critical Infrastructure Protection Center (CIPC)	November 16, 2004-February 28, 2005	$60,000
U. S. Navy-SPAWAR	Phase I: CIP Systems Engineering	April 13, 2004 –September 30, 2004	$60,000

PhD AS (SE) Student Focus

- Target Students
  - Primary – Full-time Aerospace/Defense Sector employees; industry and government
  - Secondary – Full-time students funded by government and industry research grants
- Target Students Profile
  - Engineering and other Technical degrees
  - Work experience in Aerospace/Defense sector
  - U.S. Citizens with active DoD Security Clearances

Resident SE Faculty

• Jerrell Stracener, Ph.D.	Scholar in Residence & Founding Director (Vought/Northrop Grumman)
• Steve Szygenda, Ph.D.*	Professor, Cecil H. Green Chair (AT&T Bell Labs)
• Junfang Yu, Ph.D. *	Assistant Professor (I2)
• Eli Olinick, Ph.D.*	Associate Professor
• Mitch Thornton, Ph.D.*	Professor (E-Systems Greenville)

*= Part time SE Program

SE Adjunct Faculty

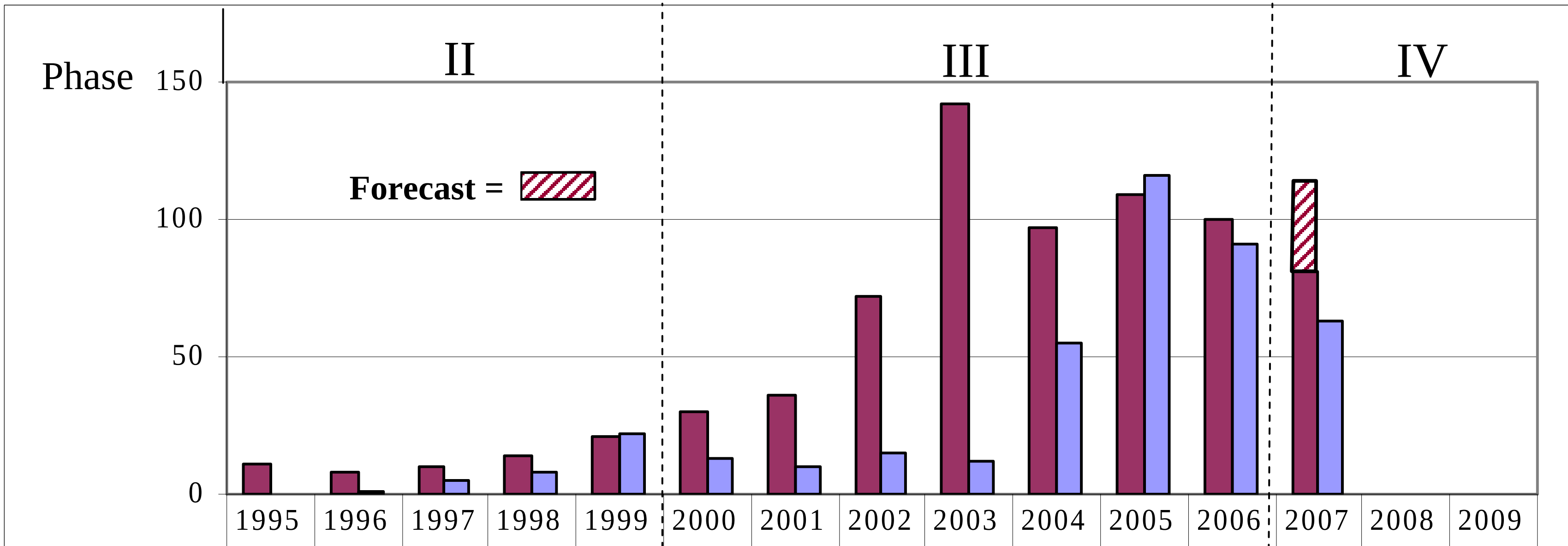
• Arunski, Karl P.E.	Raytheon Intelligence and Info. Sys.
• Bell, Bob	Lockheed Martin Aeronautics Company
• Bell, Dave , DE	Mitre
• Broihier, Ann	Raytheon Network Centric Systems
• Chollar, Jr. George , PhD	Statistical Design Institute, LLC
• Cluff, Kevin PhD, P.E.	Abbott Laboratories
• Cowin, Howard	Lockheed Martin Missiles & Fire Control
• Daley, Gunter	Siemens Government Services
• Delzer, Dennis, PhD	Raytheon Space and Airborne Systems
• Durchholz, Matt, PhD	Lockheed Martin Missiles & Fire Control
• Hinderer, Jim, PhD	Raytheon Space and Airborne Systems
• Hopper, Mike, DE	L-3 Communications Integrated Systems
• Ibarra, Gerard, PhD	Ibarra & Associates
• Lipp, John, PhD	Lockheed Martin Missiles & Fire Control

SE Adjunct Faculty continued

• Lyons, Jan, PhD	Lockheed Martin Missiles & Fire Control (Ret.)
• Muto, William, PhD	GE Medical Systems
• Oshana, Rob	Freescale Semi-conductor
• Rynas, Chris	Raytheon Space and Airborne Systems
• Sampson, Mark	Siemens Automation
• Skinner, Steve	Bell Helicopter
• Vacante, Russell	US DoD defense Acquisition University

SMU System Engineering Program

MS SE Admissions and Graduates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Admissions	11	8	10	14	21	30	36	72	142	97	109	100	81		
Graduated	0	1	5	8	22	13	10	15	12	55	116	91	63		

Cumulative admitted as of September 14, 2007: 731

Cumulative graduated as of August 15, 2007: 411

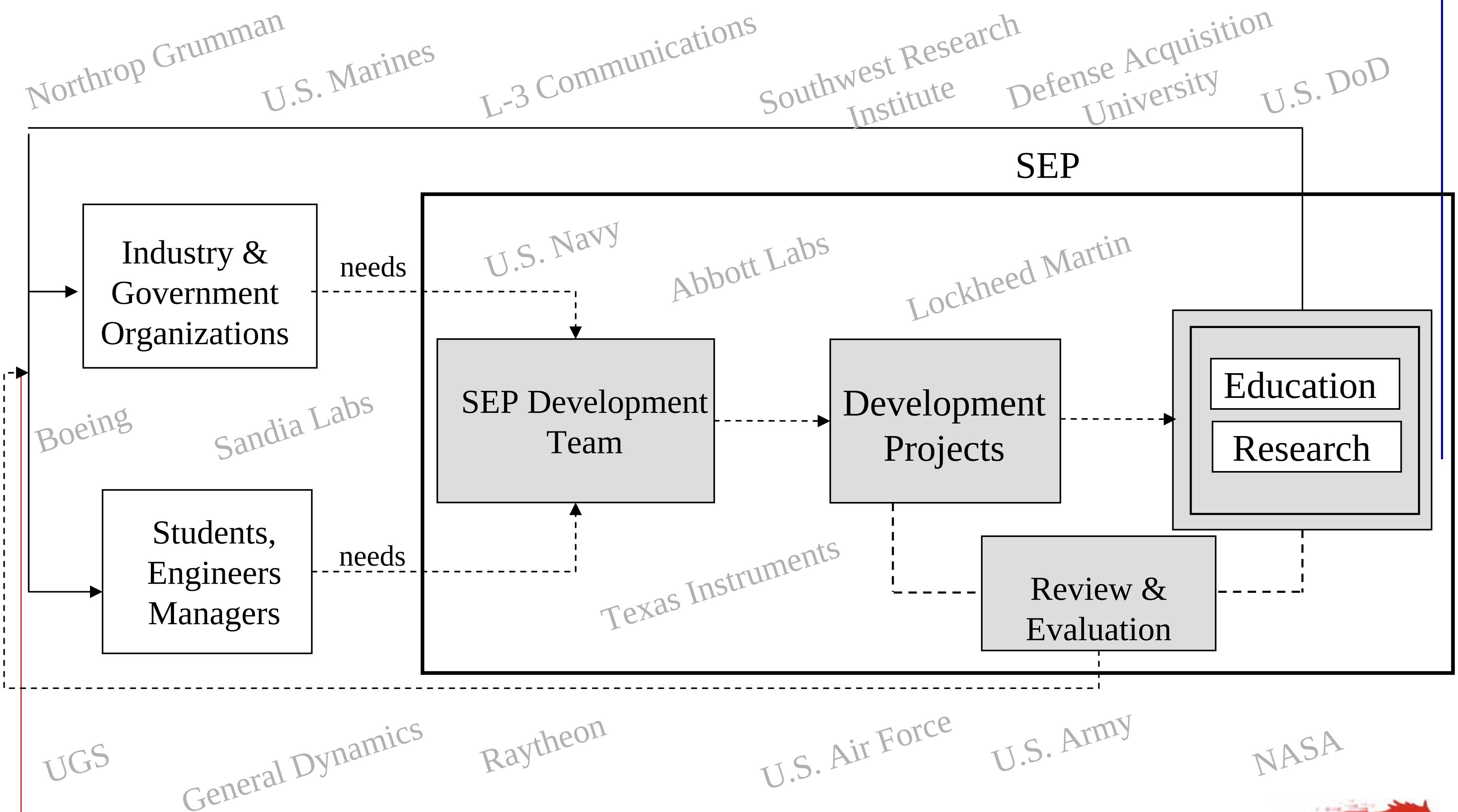
Note: Does not include NTU Students

SMU-EMIS

System Engineering Program

SEP Development

Development Model
Industry- Government - Student Partnership



SMU-EMIS
System Engineering Program

Development Highlights

- Initiated Feasibility Study………………………...September 1991
- Established ad hoc SE Advisory Council………..January 1992
- Initiated Proposal…………………………………...February 1992
- Investigated Launching SEP at…………………...April 1993
  - UT Arlington
  - UT Dallas
  - SMU

(estimated 400 to 500 admissions in first 10 years)

- Selected SMU……………………………………...June 1993
- Delivered Proposal to SMU SoE………………….July 1993
- SMU Board of Trustees Approved Proposal…...December 1994
- MS SE Degree Program Launched ………………….Jan. 1995

ad hoc Systems Engineering Advisory Council 1991-1995

Name	Organization	Location
Arunski, Karl, P.E.**	Texas Instruments, Inc.	Dallas, TX
Coyne, Bill	American Airlines	Fort Worth, TX
Davis, Joe, P.E.	Loral Vought Systems	Grand Prairie, TX
Dean, Joe, Ph.D.	Lockheed Martin Tactical Aircraft Systems	Fort Worth, TX
Halligan, Charles	General Electric Transportation Systems	Erie, PA
Hanson, Harold	EDS	Plano, TX
Harris, Doug, DE	Southern Methodist University	Dallas, TX
Jain, Anant, Ph.D.	Rockwell International	Richardson, TX
Kolson, Joanna	Federal Reserve Bank	Dallas, TX
Luhks, Ronald, Ph.D.	Loral Aerospace	Houston, TX
Martin, Kim	Abbott Labs	Irving, TX
Pearse, Derek	Hughes Training, Inc.	Arlington, TX
Ransom, C. J. , Ph.D.	Bell Helicopter Textron	Arlington, TX
Stracener, Jerrell, Ph.D.*	Vought/Northrop Grumman Corp.	Grand Prairie, TX
Shaw, Terry, Ph.D.	E-Systems	Greenville, TX
Steinheimer, Steven L.	E-Systems	Garland, TX
Tucker, Scott	Hughes Training, Inc.	Arlington, TX
Vacante, Russell, Ph.D.	Army Management Staff College	Fort Belvoir, VA
Zsak, Mike	U.S. DoD OSD	Washington, DC

***=Chairman**

****=Vice Chairman**

SEP Business Structure

- Multidisciplinary Program – Department Independent
- Build on Aerospace & Defense (A&D) Base & Needs
- Focus on part-time students employed full-time by the A&D sector – Industry & Government
- Utilize SE subject matter experts employed by A&D for Adjunct Faculty for teaching most courses - Scalable
- Grow number of resident faculty to develop SE research & PhD SE programs and teach specialized advanced SE courses

ad hoc SE Council recommendations

Development Highlights

- Phase I - Concept Exploration & Proposal (Sept 1991 – Dec1994)
- Phase II - Start-Up and Development (Jan 1995 – Dec 1999)
- Phase III - Rqmts. Driven Development (Jan 2000 – Dec 2006)
- Phase IV - Focused Development (Jan 2007 – Dec 2011)

Executive Reviews

- U.S. DoD Defense Acquisition University
  - Dr. Russell Vacante, Director
- Lockheed Martin Aeronautics
  - Tom Blakely, VP Engineering
  - Bob Manny, VP Enterprise Integration
  - Jim Engelland, VP Systems Engineering & Chief Engineer F-35
  - Frank Cappuccio, VP Advanced Development Programs
  - Bill Anderson, VP Engineering
- Lockheed Martin Missles & Fire Control
  - Glenn Miller, VP Technical Operations
  - Bill Cannon, VP Engineering
- Raytheon Information and Intellegence Systems
  - John Grimm, VP Engineering

Executive Reviews

- U.S. DoD OSD
  - Bob Skalamera, Deputy Director, Systems and Software Engineering
  - Mark Schaeffer, Deputy Director, Defense Systems, and Director, Systems Engineering, OUSD (AT&L)
  - Dr. James Roche, Secretary of the Air Force
  - Mike Zsak, Director, Systems Engineering
  - Mike McGrath, Director CALS
- Raytheon Space & Airborne Systems
  - Bob Kern, VP Engineering
  - Janne Ackerman, Director North Texas Engineering
  - Bob Rassa, Director Systems Supportability
- Vought Aircraft Company
  - Eric Smith, Senior VP Programs
  - Joe Ayers, VP Engineering
- L-3 Communications Integrated Systems
  - Dr. Val Gavito, VP Engineering & Strategic Initiatives

DAU – SMU SEP Partnerships

- U.S. DoD Defense Acquisition University (DAU) and SMU Systems Engineering Program (SEP) MoU

    1. Provide members of U.S. DoD Acquisition, Technology, and Logistics (AT&L) workforce the opportunity to apply courses provided by DAU towards a SMU graduate degree in systems engineering.
    2. Provide SMU SEP students access to DAU courses, and
    3. Collaboratively develop research topics and projects in systems engineering.

- U.S. Navy SPAWAR Charleston and SMU SEP Cooperative Research and Development Agreement (CRADA) in work

National Defense Industrial Association

SYSTEMS ENGINEERING DIVISION

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open- ManTech Int'l
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The Software Committee
Was Disbanded
Dec 7, 2003

Quality Assurance Committee
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Life Cycle Support Committee
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Raytheon
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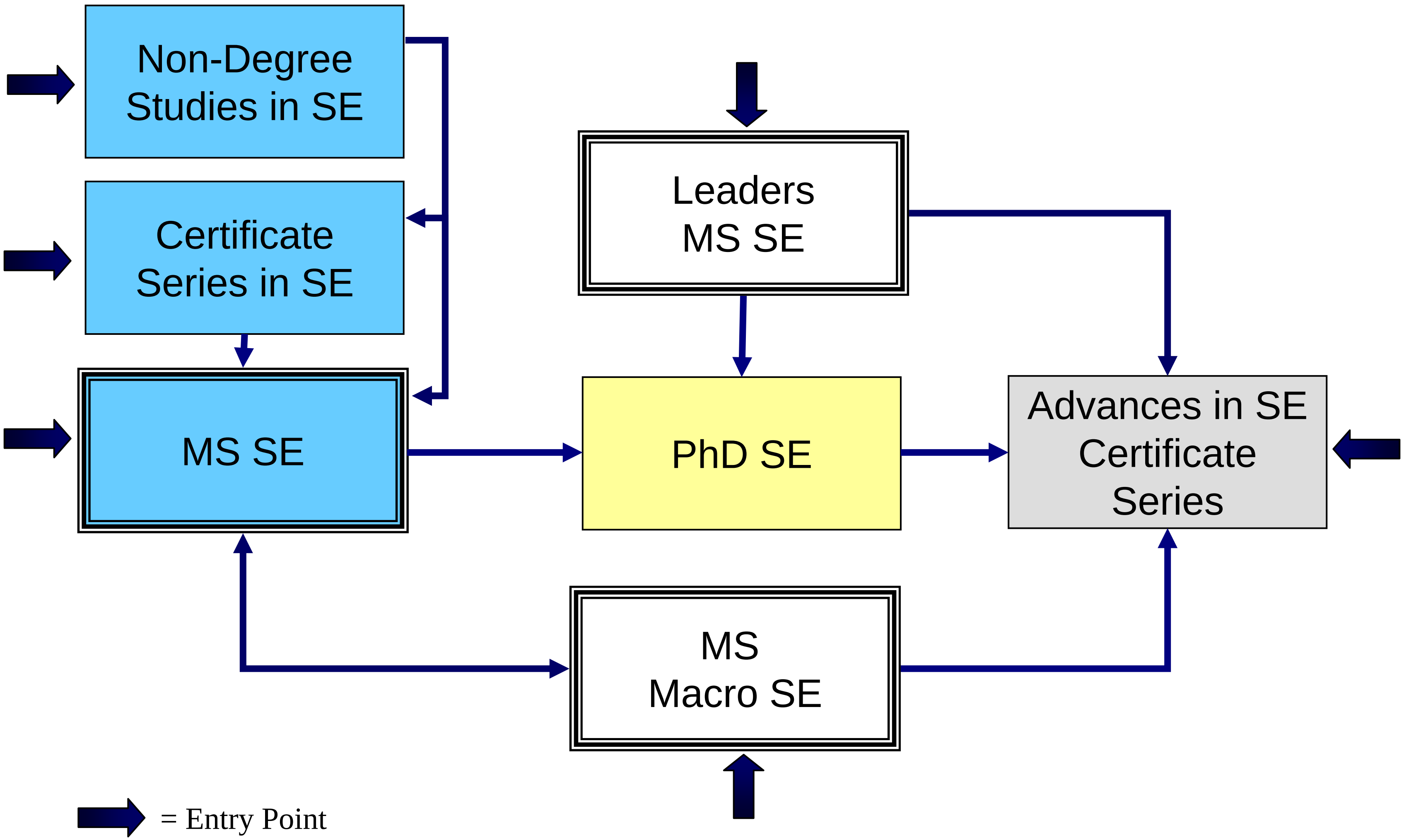
Plans

Baseline Academic Programs



Systems Engineering Education is a Journey – Not a Destination

SMU-EMIS
System Engineering Program

Summary

Summary

- A SE Education & Research program with focus on:
  - aerospace & defense
  - development of complex Systems (as opposed to acquisition)
- Track record of success in responding to Customer needs
  - SEP Established in 1994
  - Growing Enrollment and expanding scope
  - Extensive & growing industry and government network
- SE is currently a HOT topic (but lacks branding)
  - Emphasis on SE by U.S. DoD and defense contractors
  - High and increasing Student interest in SE (not in becoming a SE, but rather in utilizing SE education to become a “letter” engineer or for career advancement)
  - Increasing number of University SE Programs (but many are commingled with other programs)
- The SEP is severally resource constrained for PhD SE generation and research

Agenda

- Systems Engineering Education
    - SMU (Systems Engineering Program) Overview
    - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary

PRIVATE

Description

- Research based exploration and definition of a framework for effective response to regional industry and government systems engineering-education,-research and-training & consulting needs.
- Initial focus on the aerospace/ defense/security sectors.
- Expansion to other sectors will be guided by regional needs.

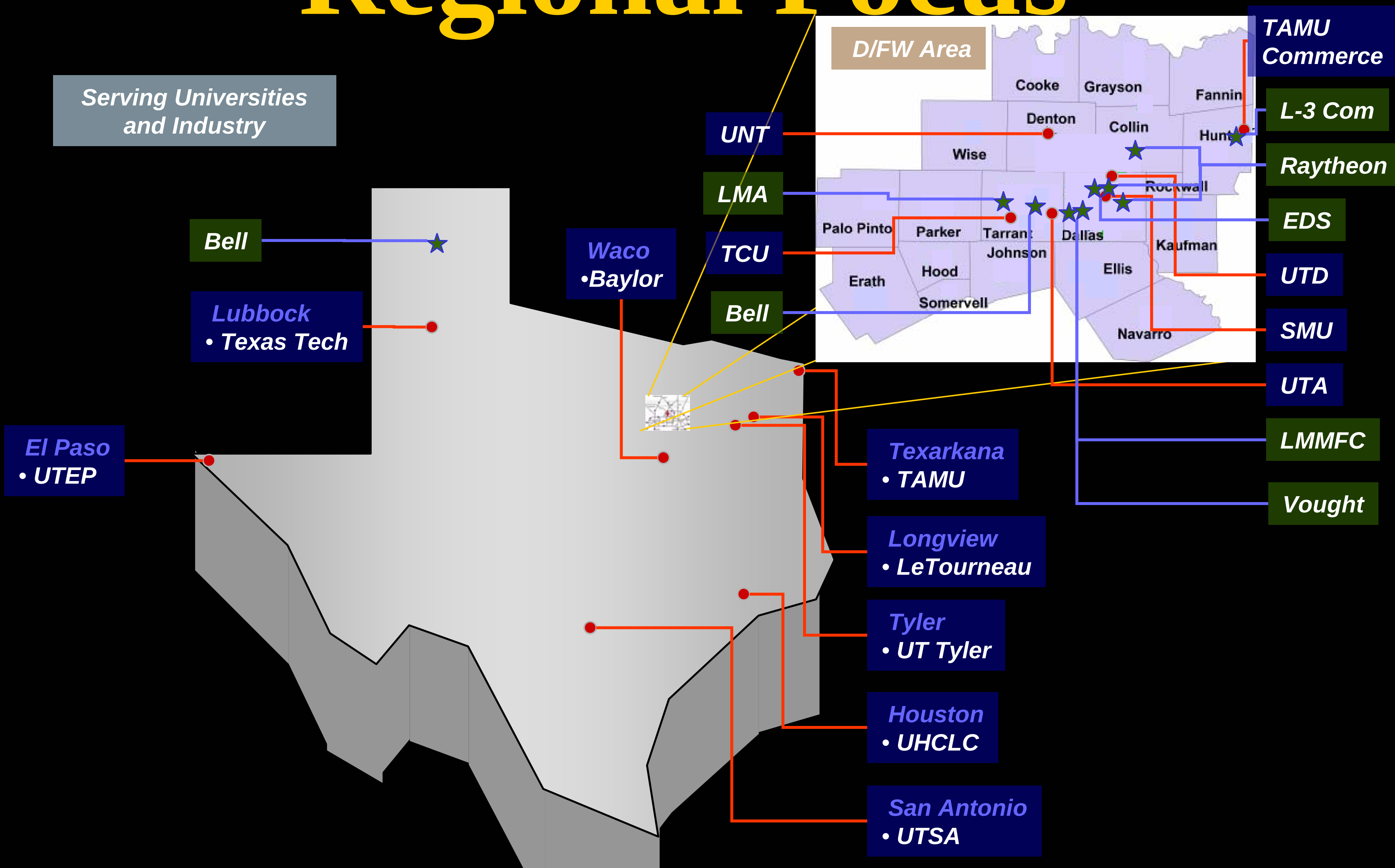
Statement of Work

PRIVATE

- Specific tasks necessary to evolve the preferred response framework include the following:
  - Industry and government needs captured and assessed
  - Identification and analysis of regional capabilities and resources, both current and planned
  - Analysis to determine gaps and overlaps with respect to needs
  - Explore and define alternatives for responding to needs, including benchmarking the nations best.
  - Evaluate and refine alternates to evolve the preferred concept, a regional framework.
  - Strawman regional framework development plan
- To ensure a structured technical approach and balanced solution, the systems engineering process will be utilized in the planning and conduct of this research project.

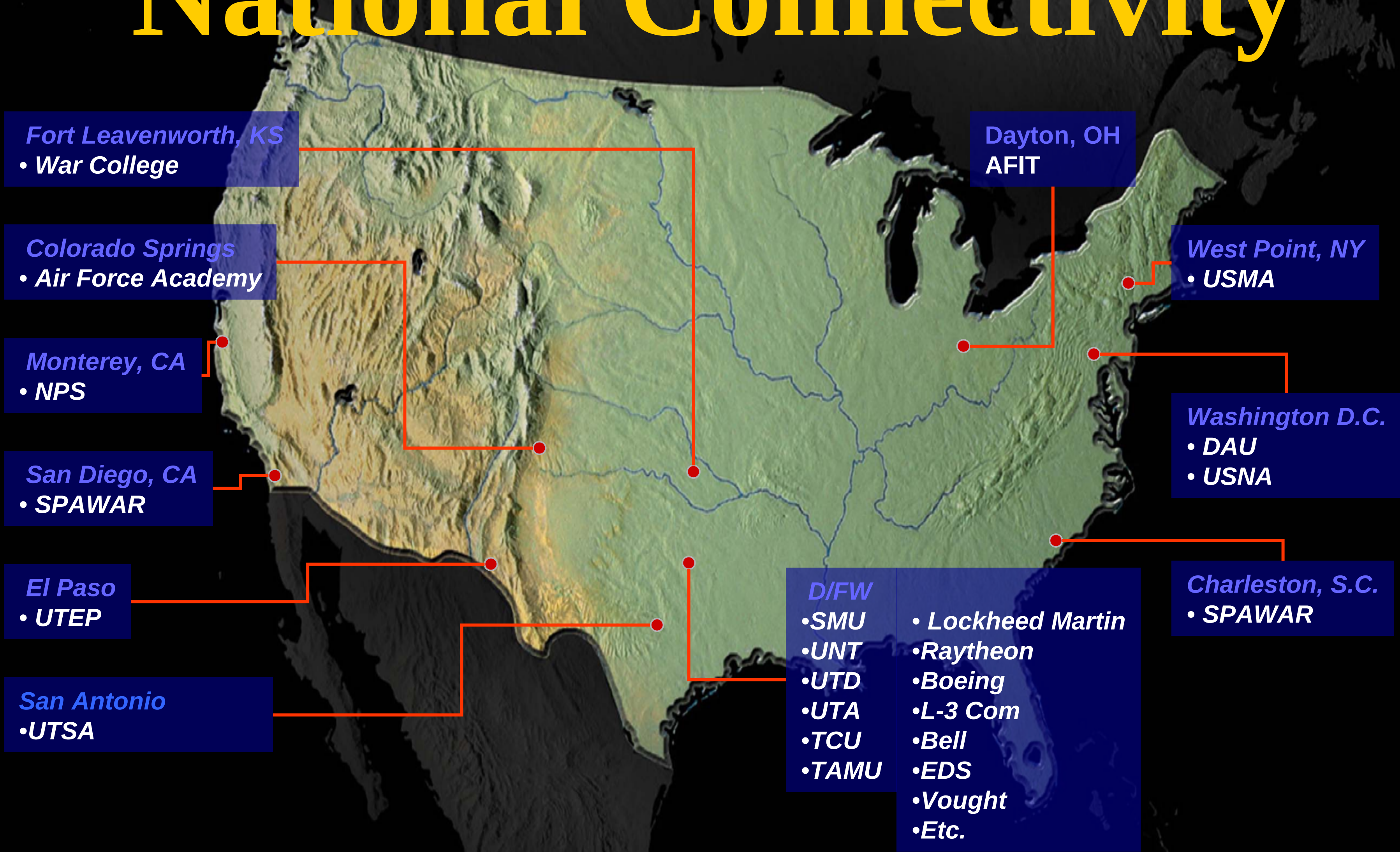
ad hoc
Systems Engineering
TIGER TEAM

Regional Focus



Leveraging Regional Capabilities to Meet Regional Needs

National Connectivity



Regional Center with National Ties

Mobilize Resources and Build on Experience

PRIVATE

- Initiate SE Tiger Team of members Industry, Government and University Affiliations
- Utilize Previous Start-Ups as Guides
  - SAE RMSL Division (G-11): 1985 - 2000
  - CALS Connectivity Center (CCC) / UTA ARRI: 1989 - 1999
  - SMU Systems Engineering Program: 1991 - Present

ad hoc
Systems Engineering
TIGER TEAM

Organization

Executive Board
- Tom Blakely, LM Aeronautics
- Val Gavito, L-3 Com Integrated Systems
- *Mark Schaeffer, DoD OSD

Team Leader
- Jerrell Stracener, SMU

Advisors
- John Weaver, LM Aeronautics
- Steve Szygenda, SMU
- Russell Vacante, DoD DAU
- Don Liles, UT Arlington

SE Education
- Gunter Daley, Siemens Govt Services
- Karl Arunski, Raytheon IIS

SE Center
- Bret Early, LM Aeronautics
- Walt Hamaker, Bell Helicopter

Benchmarking
- Tim Woods, LM Aeronautics
- Jim Hinderer, Raytheon SAS

SE Research
- Mike Harper, US Navy SPAWAR
- Chris Gould, LM Missiles & Fire Control

Business Case
- Bill Rhoades, Vought (Ret.)
- Brent Wells, Raytheon SAS
- Larry Stephens, LM Missiles & Fire Control

Needs & Requirements
- Keith Castleberry, Boeing Company
- Denise Ayers, L-3 Com Integrated Systems

SE Training & Consulting
- Jeff Williams, Bell Helicopter
- Raytheon NCS*

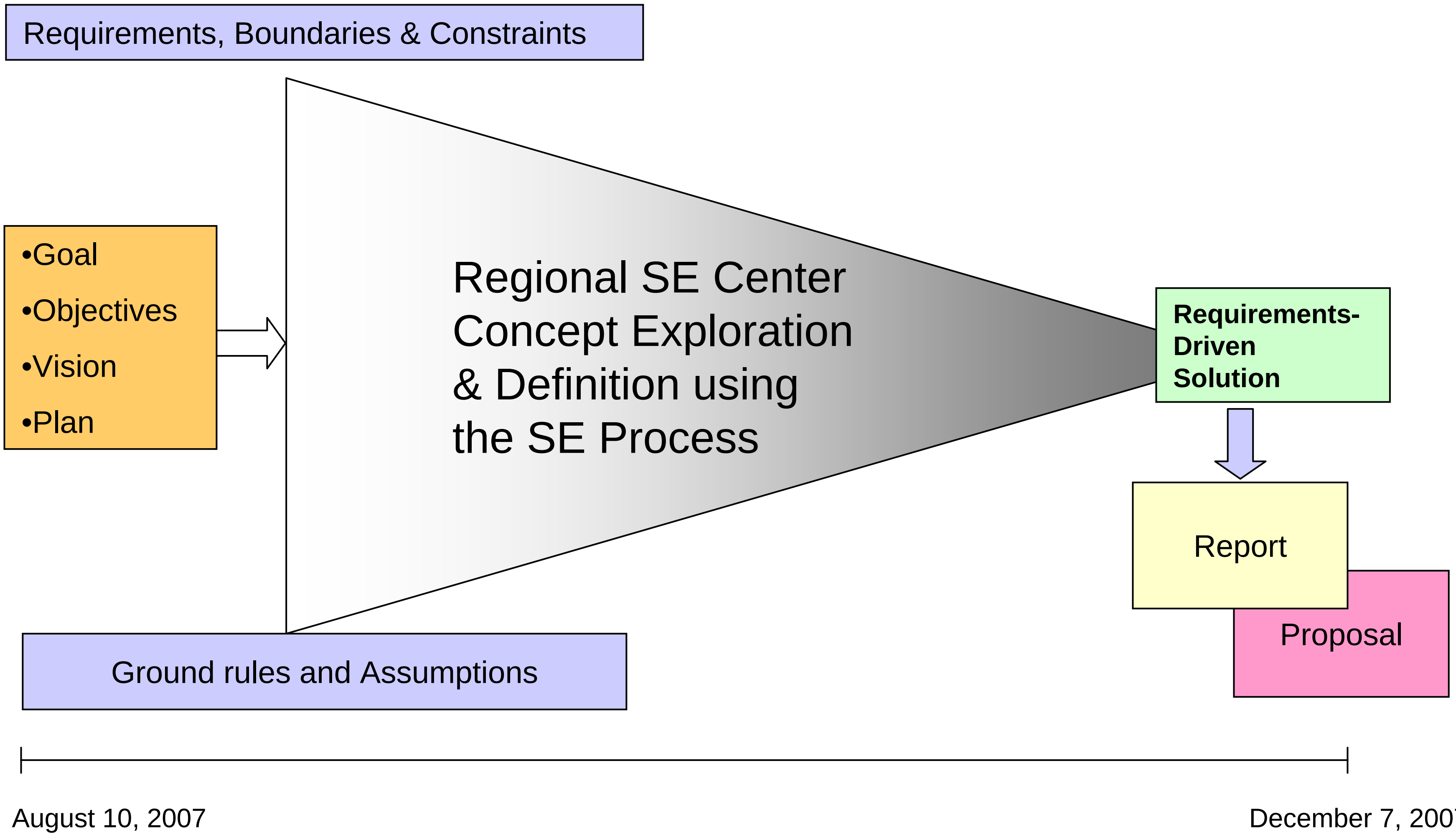
Integration and Reports
- Chris Askew, LM Missiles & Fire Control
- Chris Thompson, IBM

organizational affiliation – not representation

*= to be invited

Research Process

PRIVATE



PRIVATE

Vision

Advancing SE Technology

SE Think Tank

Center for Systems Engineering

Texas Engineering Work Force Advancement

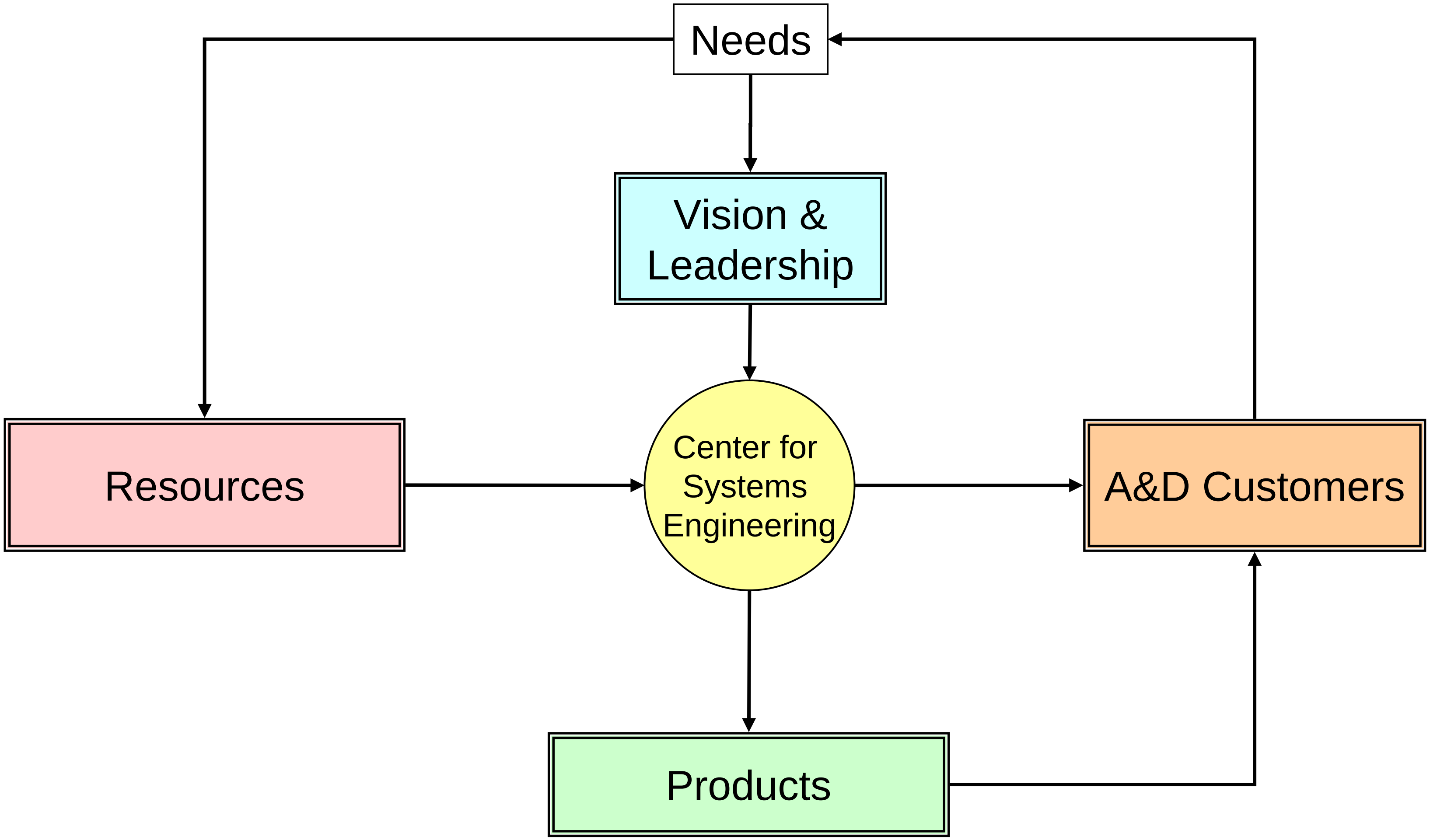
An Industry-Government-University Partnership to Improve Development of Complex A&D Systems

A National Center With Regional Focus

ad hoc
Systems Engineering
TIGER TEAM

Center for SE – Functional Concept – Overview

PRIVATE



Agenda

- Systems Engineering Education
    - SMU (Systems Engineering Program) Overview
    - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary

Training Goal

to provide System Engineering training that is

- Tailored to customer needs and work place
- Delivered by industry, government and academia subject matter experts
- Relevant
- Conducted in an interactive workshop format

Training Objective

- to increase Systems Engineering awareness
- to increase organizations Systems Engineering capability
- to increase individual engineers SE expertise

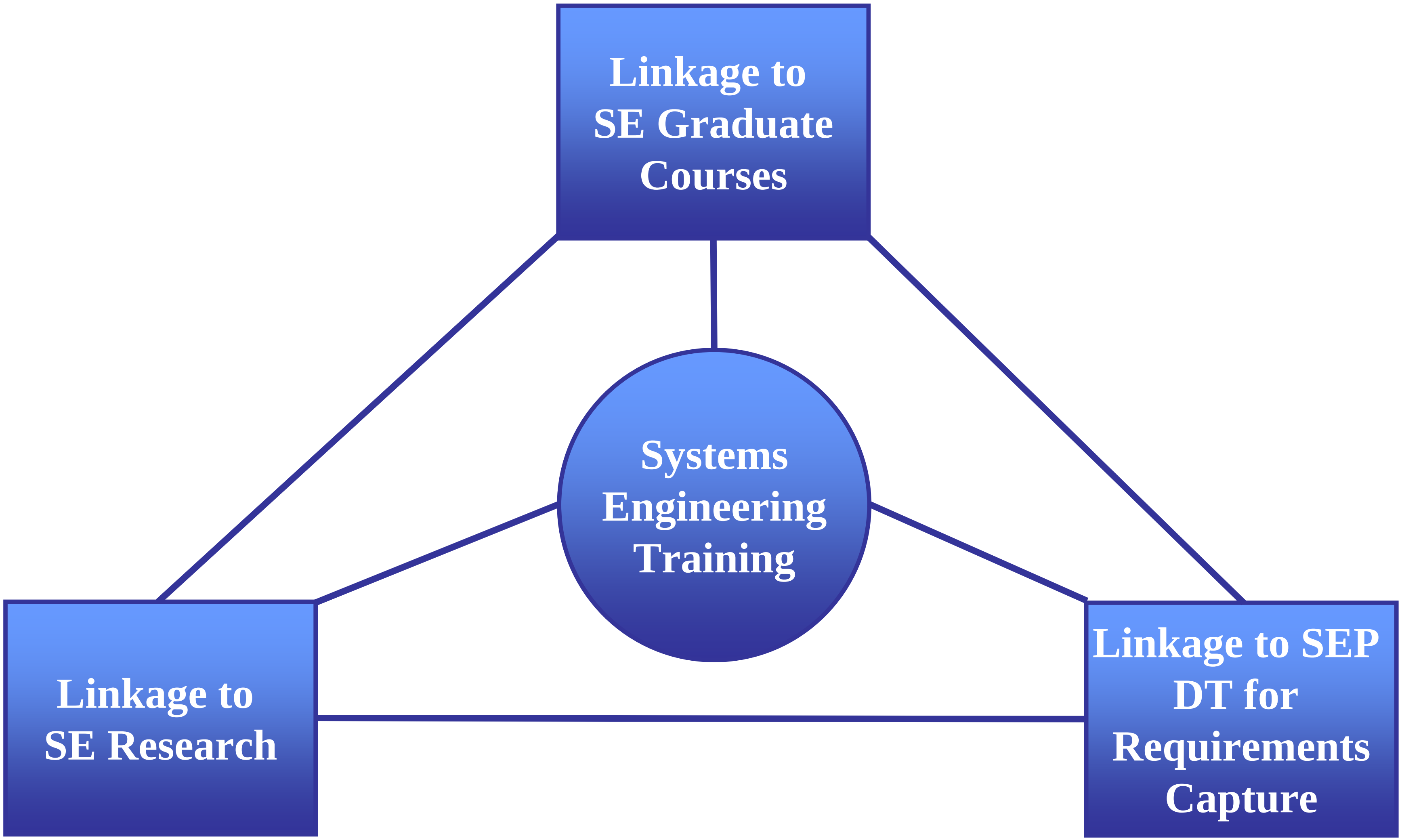
Training Scope & Delivery

System Engineering training Scope

- Integrated program
- Stand-alone modules
- Special aligned systems engineering topics

- Delivery
  - JGR Systems Engineering, LLC

Leveraged and Work-Place Relevant Training



Organizational Level, Training “Depth” and Value

Division or Department level

- Strategic or tactical business importance
- Overall value to a group, division, or department.

@ the Immediate Supervisor, Branch head or Project Lead level

- Impact on projects/programs
- Impact on employee competence

@ the individual engineer’s level

- Impact on the individual’s specific competency; e.g., ability, capabilities, skills
- Value of those competencies to the company

Systems Engineering Courses

Customer Tailored training from 1 – 5 days, in increments of one day

- Systems Analysis Methods
- Systems Engineering Process
- Integrated Risk Management
- Systems Reliability, Supportability and Availability Analysis
- Systems Integration and Test
- Systems Engineering Design
- Software Systems Engineering
- Systems Architecture Development
- Systems Engineering Leadership
- Systems Reliability Engineering
- Human-Systems Integration
- Logistics Systems Engineering

Systems Engineering Courses

- Critical Infrastructure Protection/Security Systems Engineering
- Systems Engineering Software Tools
- Six Sigma Systems Engineering
- Supply Chain Systems Engineering
- Systems Test and Evaluation
- Systems Engineering Planning and Management
- Systems Cost Engineering
- Systems Life Cycle Logistics
- Innovative Systems Design
- Systems Modeling and Simulation
- Systems Prognostic and Health Management
- Systems Development Program Engineering and Management

Summary

- Work-place Relevant Systems Engineering Training
  - By Subject Matter Practioners
  - Tailored to Customer Needs
- Linkage to Graduate Systems Engineering Courses
- Aerospace & Defense focused

Agenda

- Systems Engineering Education
  - SMU (Systems Engineering Program) Overview
  - Program Development
- Systems Engineering Aerospace & Defense Initiative
- Systems Engineering Training
- Summary

NDIA 10th Annual Systems Engineering Conference

"Discussion of the US Army RDECOM APS Objective Trade Study"

October, 2007

Frank Salvatore
High Performance Technologies, inc.
3159 Schrader Road
Dover NJ, 07801
(973) 442-6436 ext 249
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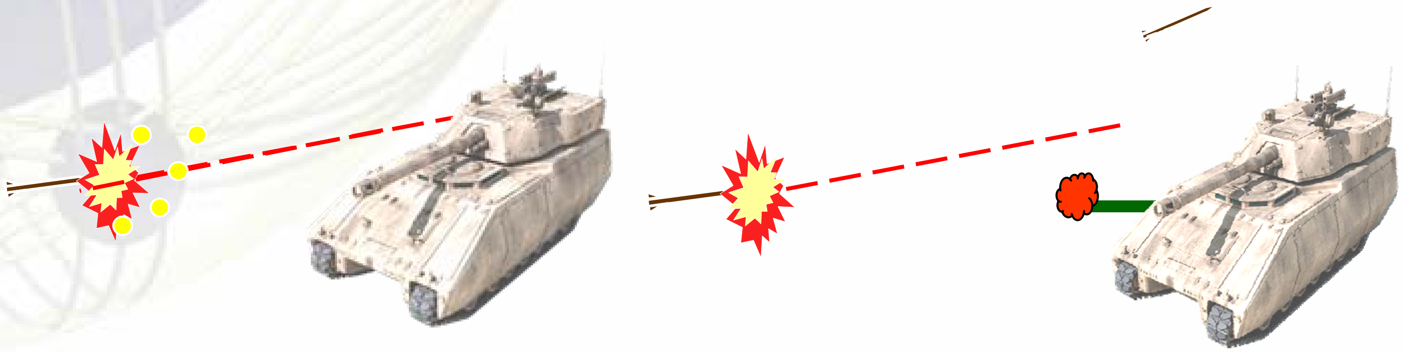
Outline

- ❑ Study Description
- ❑ Trade Study Process
  - ✓ IPT
  - ✓ Tools Developed
  - ✓ APS Architectures
  - ✓ Trade Study Tool Architecture
- ❑ Summary

APS Trade Study Description

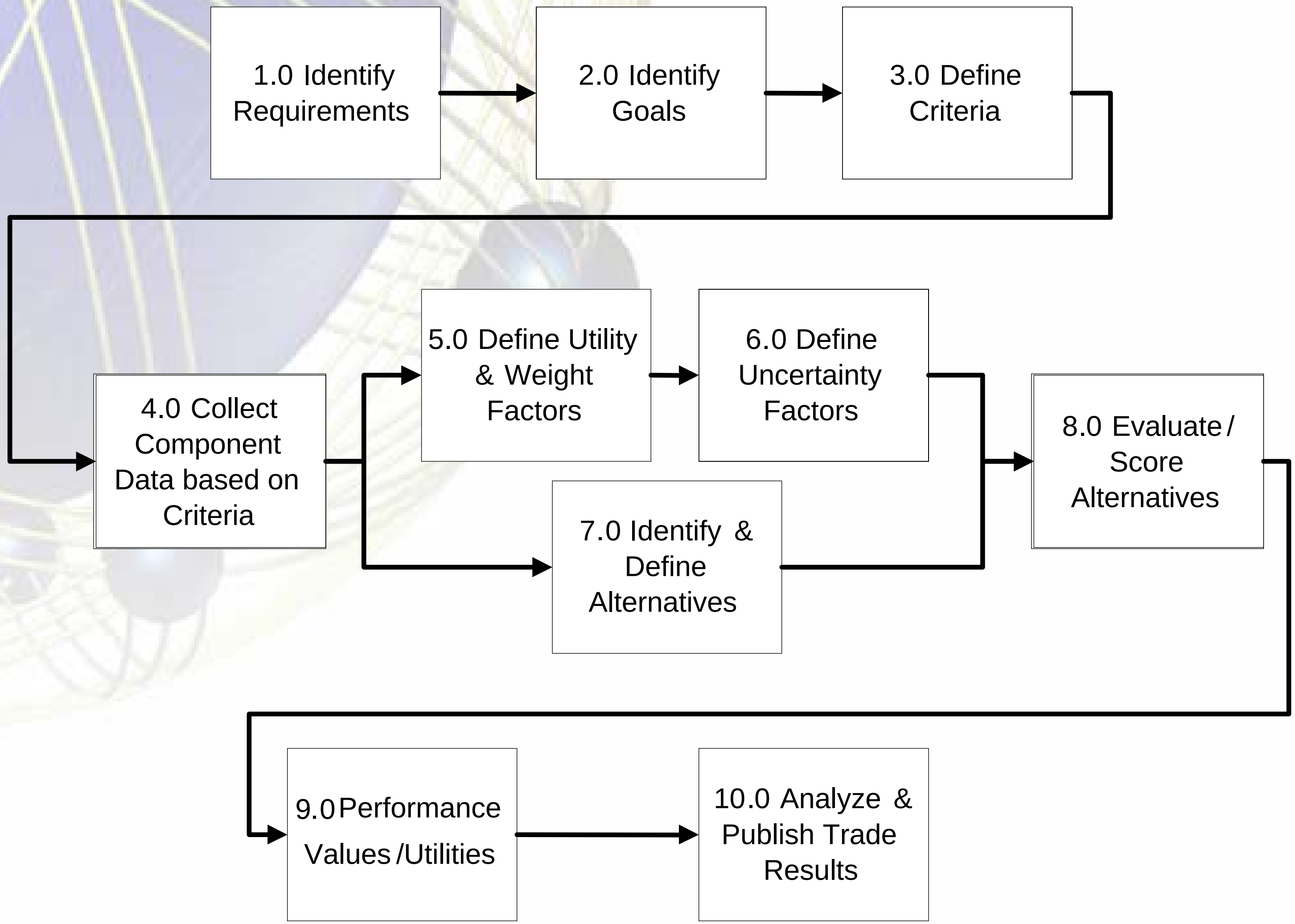
RDECOM effort led by the ARDEC System Engineering Directorate

Identify, define, and evaluate potential Universal (Objective) Active Protection System (APS) approaches for the Future Combat System (FCS).



Provide decision makers the tools/data to help identify RDECOM's Science and Technology investments needed to get to an objective APS system.

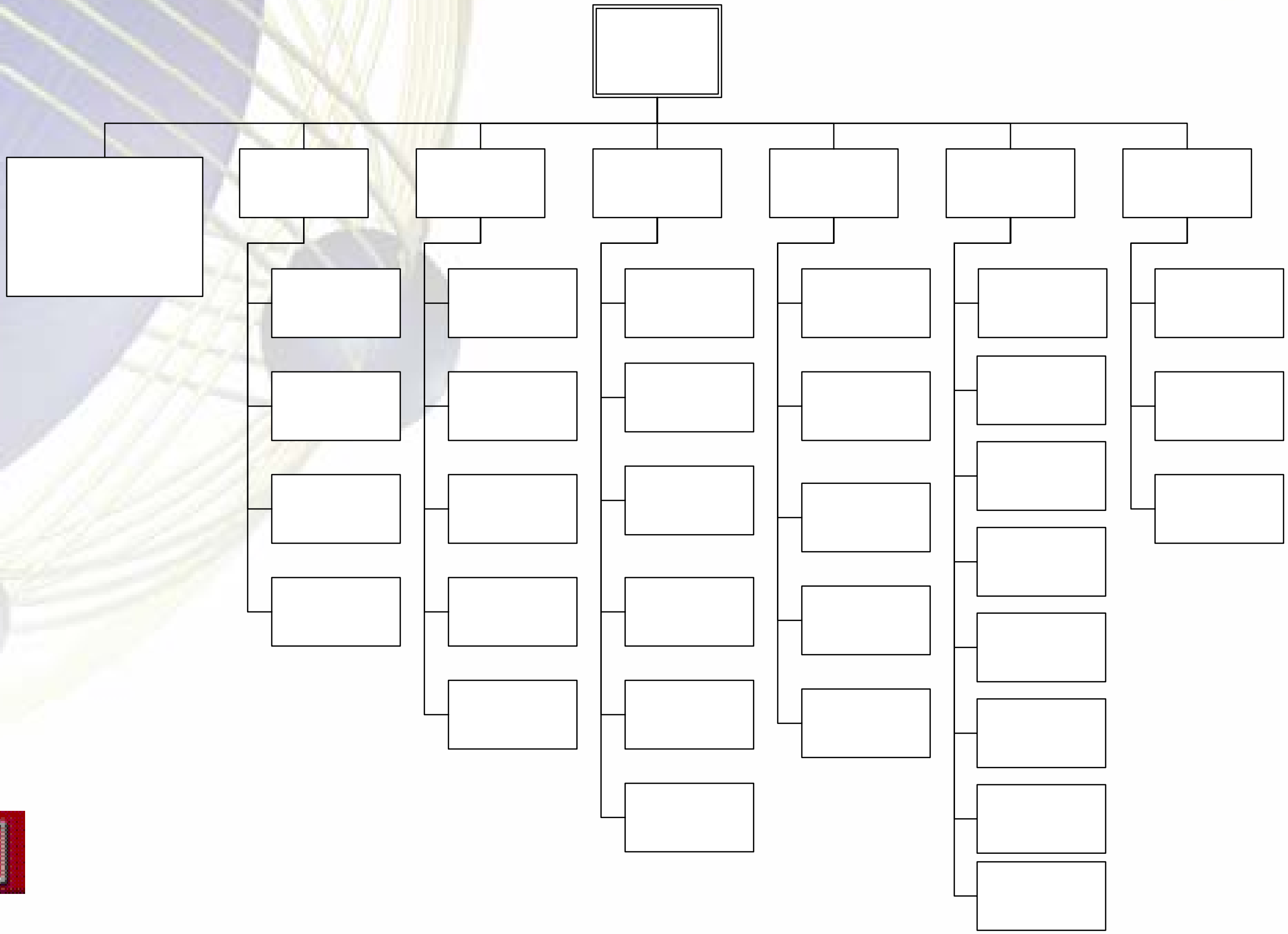
Trade Study Process



Trade Study Based on Disciplined & Structured Process

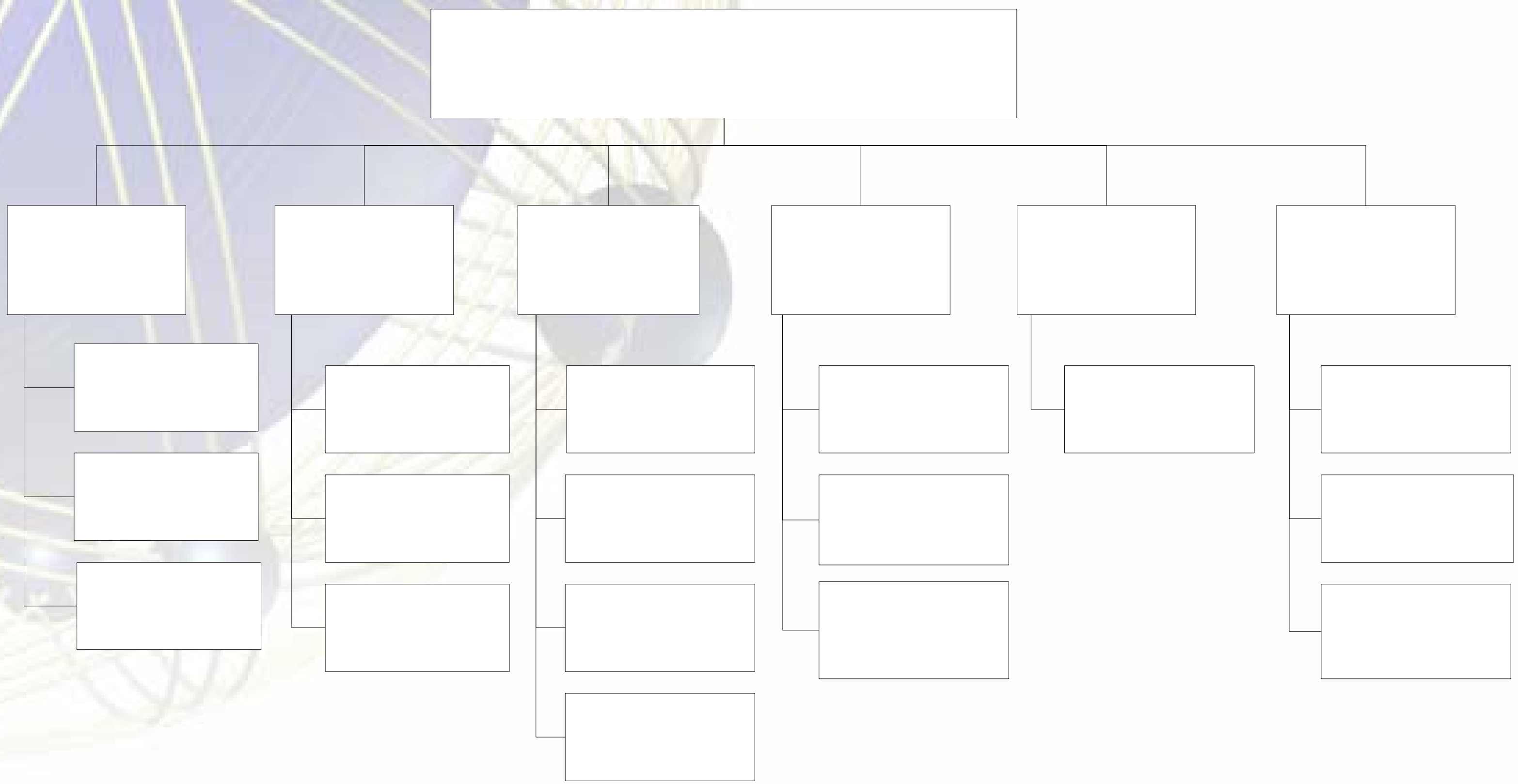
Used an IPT approach

ARDEC



The Trade Study was a Team Effort

1.0-2.0-3.0 -5.0 Requirements – Goals – Criteria - Weights & Utility



Requirements and Stakeholders Drive Decision Criteria

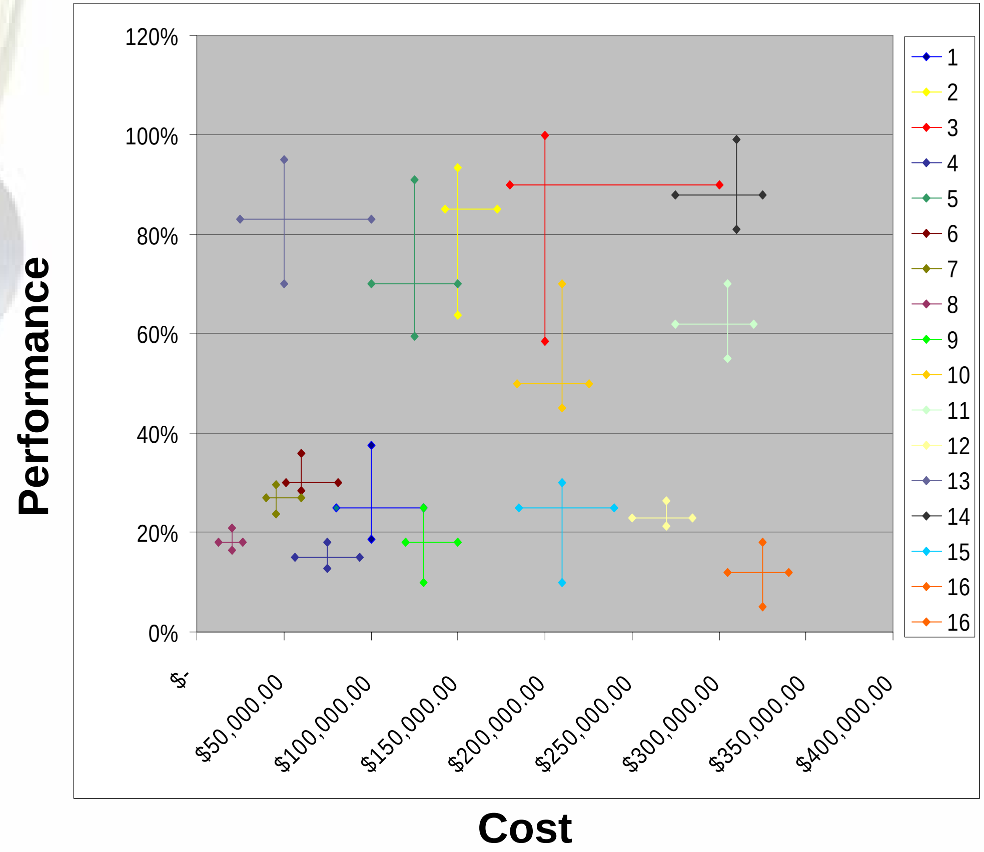
4.0 Collect Component Database on Criteria

- Technologies list build based on surveying R&D community thru several technical interchange meetings.
  - Technology specific performance characteristics established
  - Data call to Industry and Government
- Series of Data Validation meetings to confirm data used in study was accepted by community.
  - Performance Values
  - TRL

This took a lot of coordination and cooperation between Government and Industry to get right!!!!

6.0 Define Uncertainty Factors

- Data Uncertainty assessed by determining:
  - ✓ **Component TRL**
  - ✓ **Data Confidence**
- Data Uncertainty applied to criteria scores to determine plus and minus range



Data uncertainty helped visualize Results and risk!!!

7.0 Identify & Define Alternatives

- List Systems/Components
- Previous Trades
- Component Data
- Requirements

(4) → **Candidate Systems 7.1**

- Integrate System Candidates
- Organize Component Data
- ID Functional Architectures

- Existing Systems
- Analysis Method,Tools
- System Assumptions

→ **Evaluate Candidates 7.2**

•Analyze System Candidate Potential
- Timeline
- Accuracy
- Component Compatibility

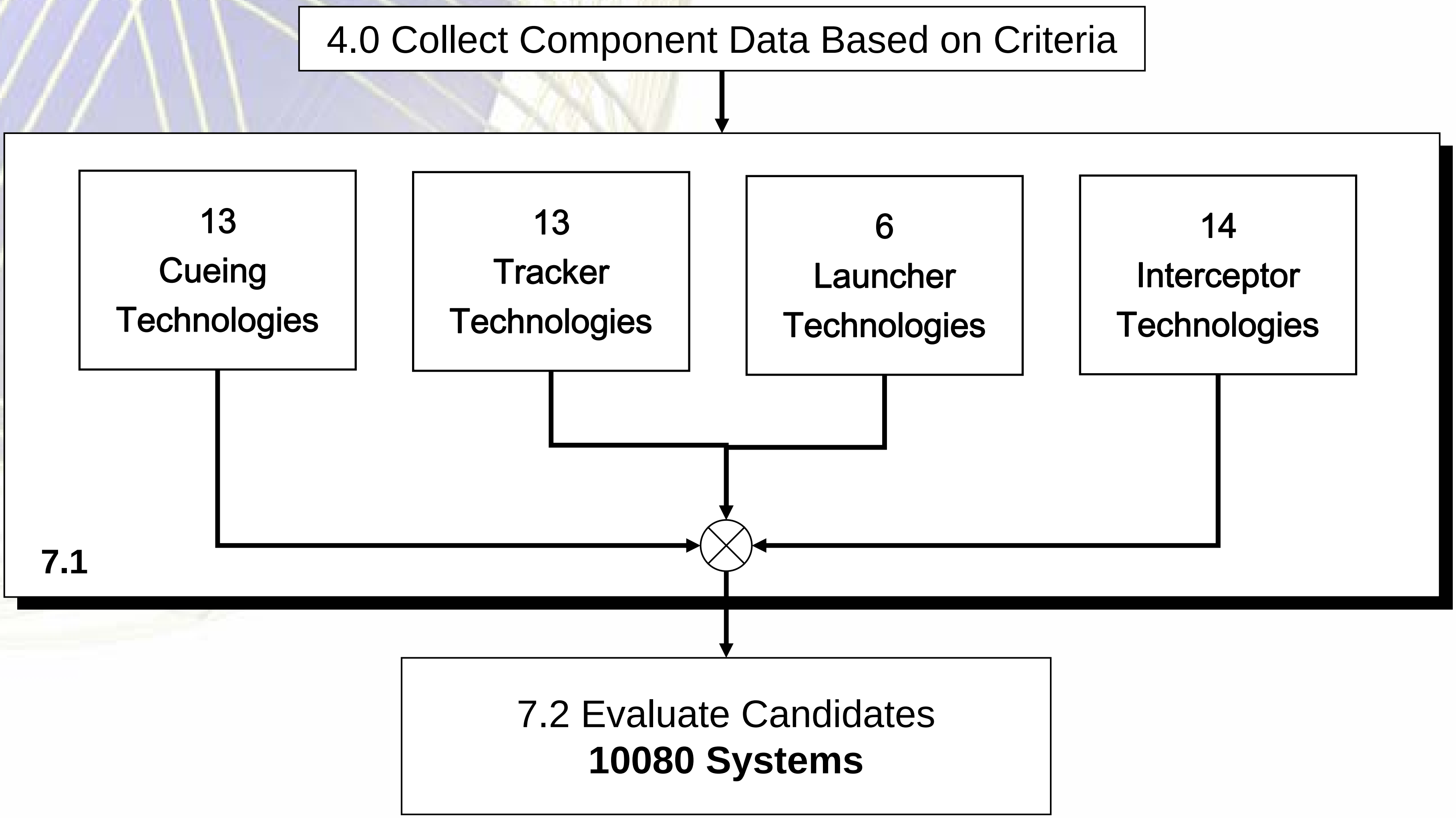
- System Alternatives
- System ID

→ **Define Alternatives 7.3** → (8)

Reach Consensus

System and Technology Architectures Required!!!!!

7.1 Candidate Systems



All Technology Combinations Were Evaluated

Function Definitions (1 of 2)

Function	Definition
Detect, Acquire	Measure and report an event not due to ambient noise
Declare	Measure and report an persistent object that should be tracked
Classify	Measure and report what the persistent object is either by class or specific type/item.
Coarse Track	Measure and report an object and determine that it’s trajectory point of closest approach to our platform is threatening. Classify and coarse track may be based on the same measured data set and completed at the same time
Initial Slew	Initial slew of launcher to launch position using fire control solution based on coarse track
Initial Tube Selection	Initial designation of launch tube or tubes in fixed system that need to be “warmed up” using fire control solution based on coarse track
Fine Track	Measure and report a target to enable calculation of a fire control solution
Fine Slew & Fire Control	Slew launcher to final position and launch an interceptor loaded with any required flight path, terminal guidance, and fuzing information
Final Tube Selection & Fire Control	Final designation of launch tube in fixed system and launch an interceptor loaded with any required flight path, terminal guidance, and fuzing information

APS system functions defined from all technology components and systems studied.

Function Definitions (2 of 2)

Function	Definition
In-Flight Track	Measure and report a target trajectory to provide in-flight guidance to an interceptor
No-Op	“No operation” - used to designate function not performed
In-Flight Guidance	Propulsion to change flight path of interceptor
Terminal Track	Measure and report a target trajectory to provide terminal guidance & fuzing updates to an interceptor
Terminal Guidance & Fuze	Orient (focus) the warhead to produce the desired effect & initiate the effect at the prescribed time and / or the prescribed distance from target
Warhead Effect	Target negation

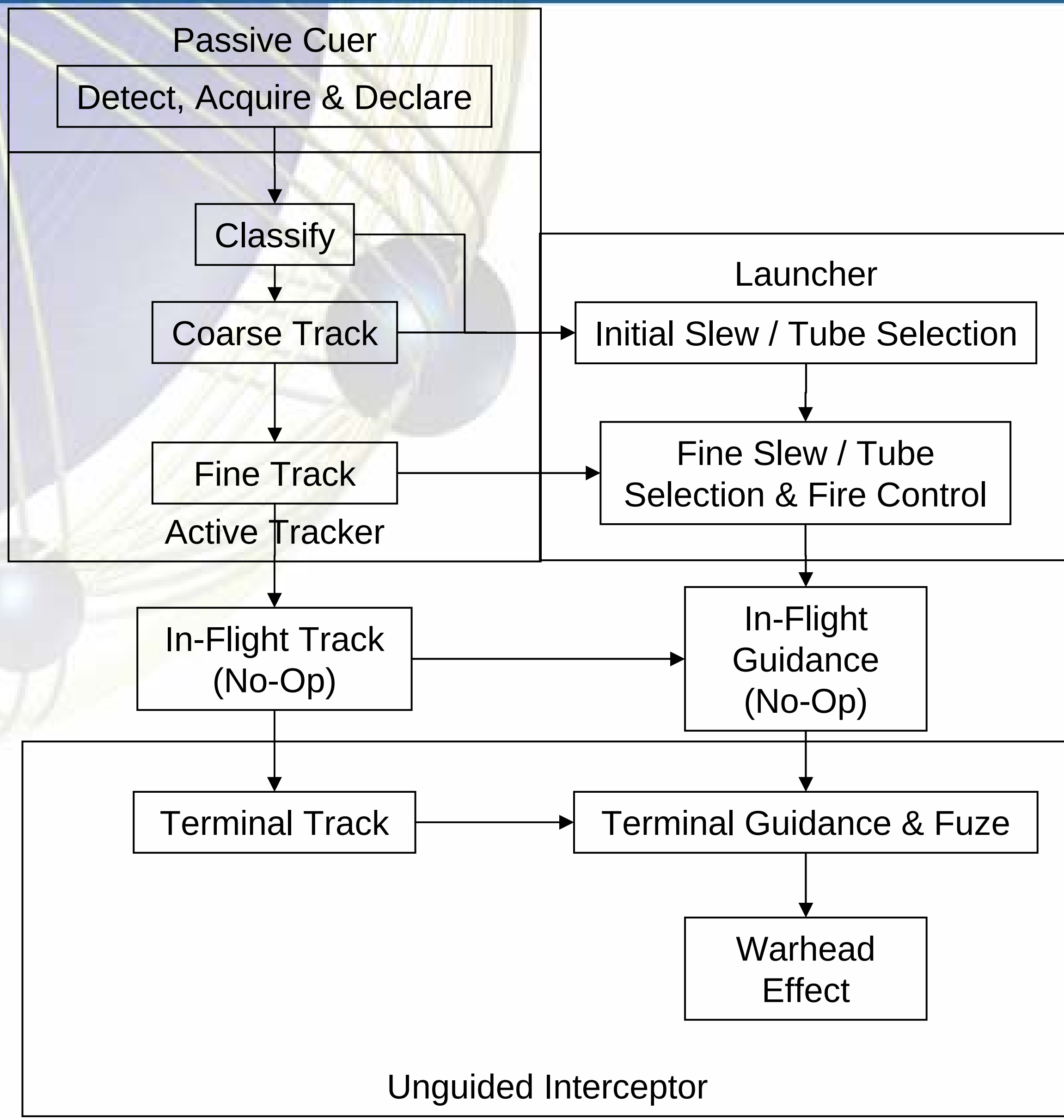
APS system functions defined from all technology components and systems studied.

Generic APS Architectures

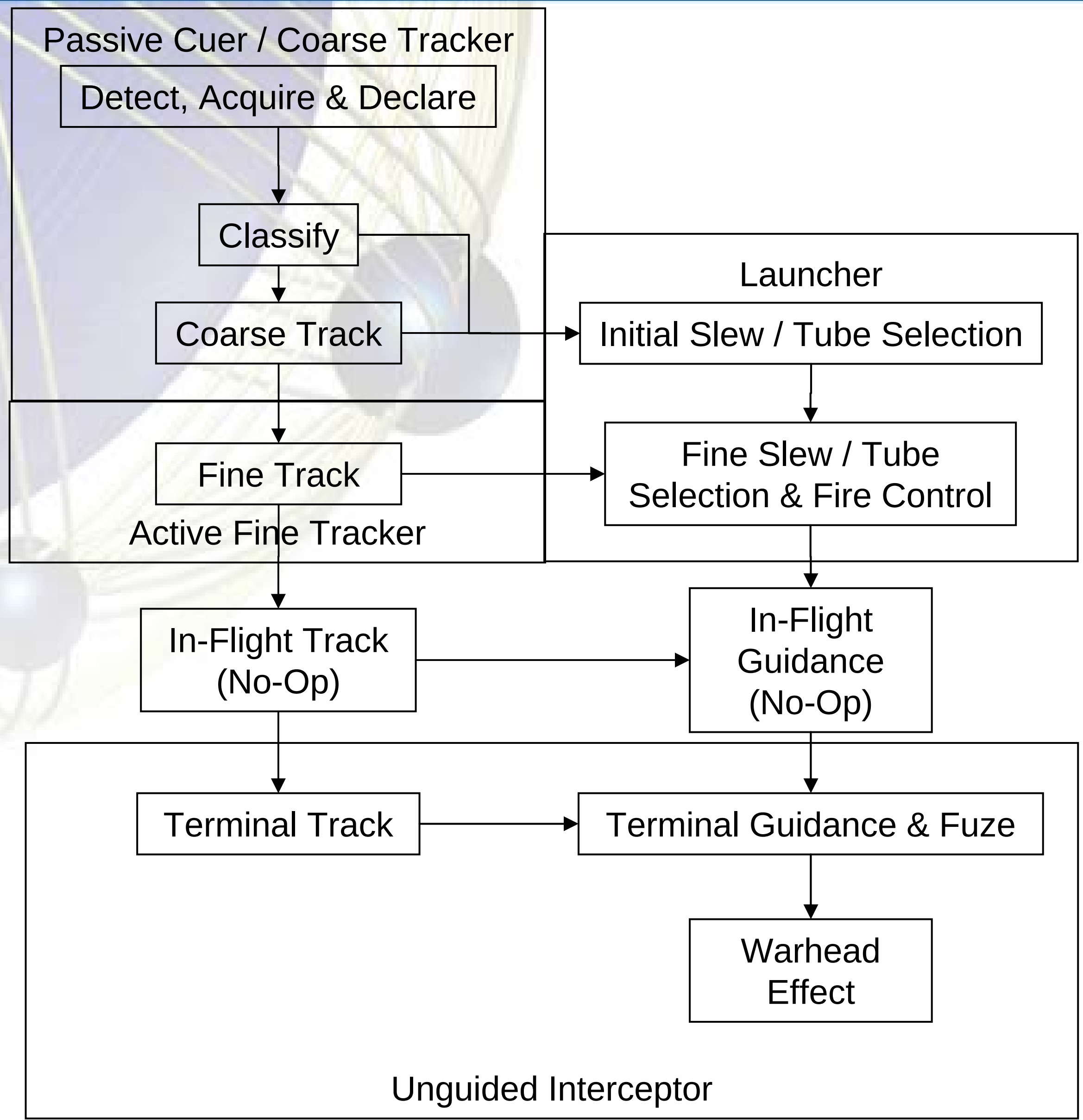
<table>
<tr><th colspan="2"></th><th colspan="4">Architectures for Unguided Interceptors</th><th colspan="4">Architectures for Guided Interceptors</th></tr>
<tr><th colspan="2"></th><th>U1</th><th>U2</th><th>U3</th><th>U4</th><th>G1</th><th>G2</th><th>G3</th><th>G4</th></tr>
<tr><td rowspan="11">System Functions</td><td>Detect, Acquire & Declare</td><td>Passive Cuer</td><td rowspan="3">Passive Cuer / Coarse Tracker</td><td>Passive Cuer</td><td rowspan="3">Active Cuer / Tracker</td><td>Passive Cuer</td><td rowspan="3">Passive Cuer / Coarse Tracker</td><td>Passive Cuer</td><td rowspan="3">Active Cuer / Tracker</td></tr>
<tr><td>Classify</td><td rowspan="2">Active Tracker</td><td rowspan="2">Passive or Active Coarse Tracker</td><td rowspan="2">Active Tracker</td><td rowspan="2">Passive or Active Coarse Tracker</td></tr>
<tr><td>Coarse Track</td></tr>
<tr><td>Initial Slew / Tube Selection</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td></tr>
<tr><td>Fine Track</td><td>Active Tracker</td><td>Active Fine Tracker</td><td>Active Fine Tracker</td><td>Active Cuer / Tracker</td><td>Active Tracker</td><td>Active Fine Tracker</td><td>Active Fine Tracker</td><td>Active Cuer / Tracker</td></tr>
<tr><td>Final Slew / Tube Selection & Fire Control</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td><td>Launcher</td></tr>
<tr><td>In-Flight Track</td><td rowspan="2">None</td><td rowspan="2">None</td><td rowspan="2">None</td><td rowspan="2">None</td><td>Active Tracker</td><td>Active Fine Tracker</td><td>Active Fine Tracker</td><td>Active Cuer / Tracker</td></tr>
<tr><td>In-Flight Guidance</td><td>Guided Interceptor</td><td>Guided Interceptor</td><td>Guided Interceptor</td><td>Guided Interceptor</td></tr>
<tr><td>Terminal Track</td><td rowspan="3">Unguided Interceptor</td><td rowspan="3">Unguided Interceptor</td><td rowspan="3">Unguided Interceptor</td><td rowspan="3">Unguided Interceptor</td><td>Active Tracker</td><td>Active Fine Tracker</td><td>Active Fine Tracker</td><td>Active Cuer / Tracker</td></tr>
<tr><td>Terminal Guidance & Fuze</td><td rowspan="2">Guided Interceptor</td><td rowspan="2">Guided Interceptor</td><td rowspan="2">Guided Interceptor</td><td rowspan="2">Guided Interceptor</td></tr>
<tr><td>Warhead Effect</td></tr>
</table>

Functional allocation to components provided context for data provided on specific components and was critical in both the Timeline and Accuracy Analysis.

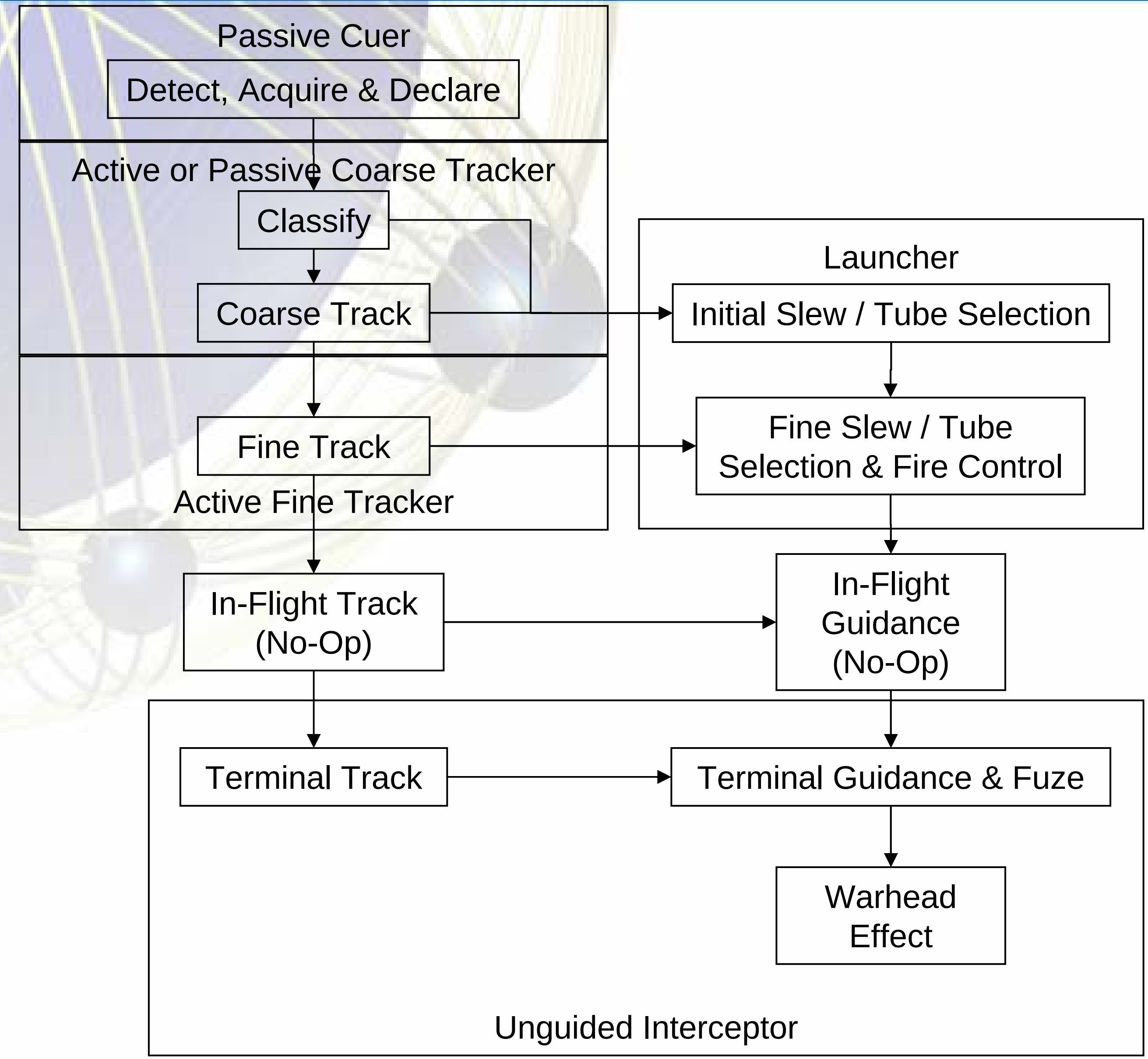
Architecture U1



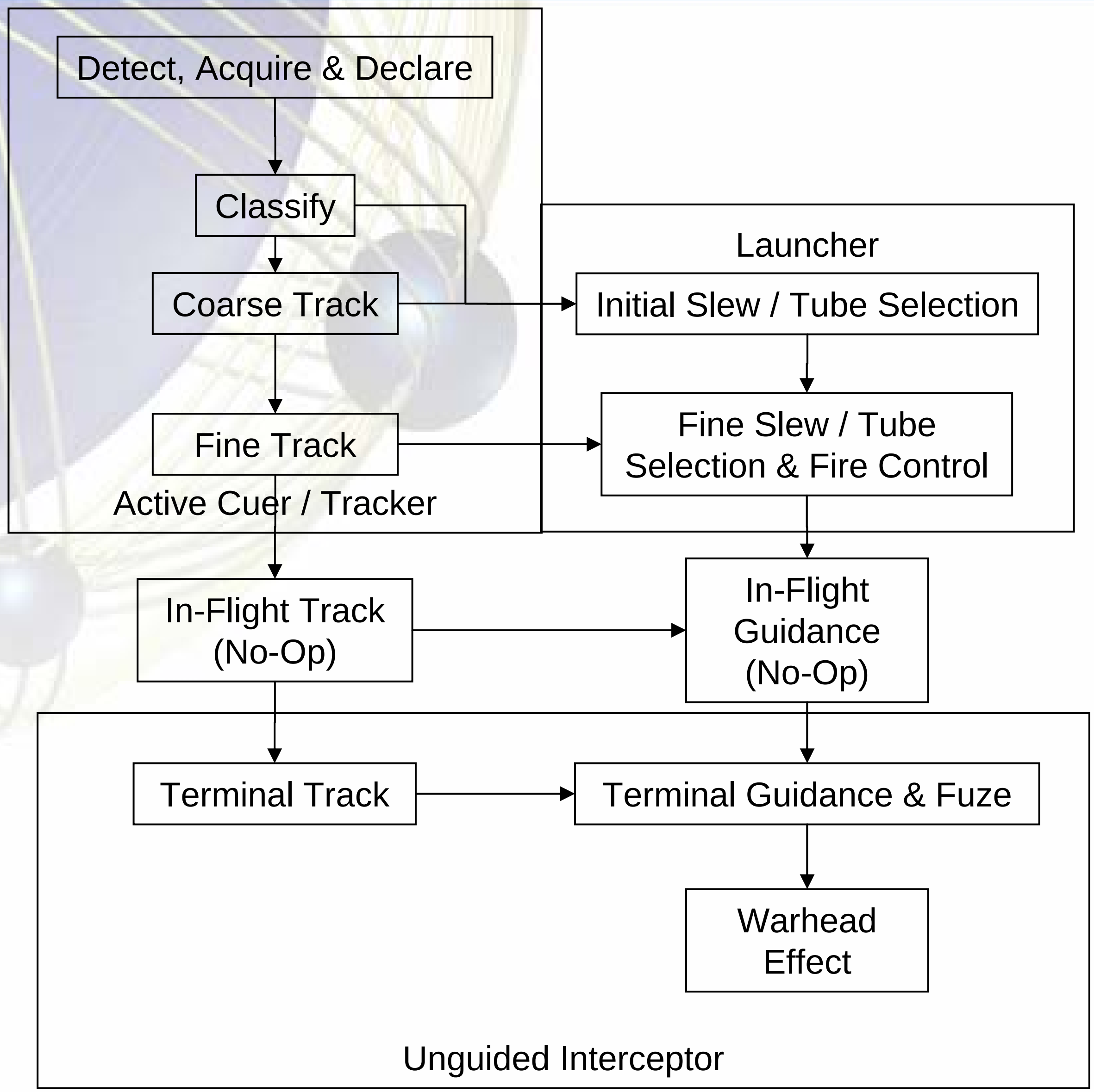
Architecture U2



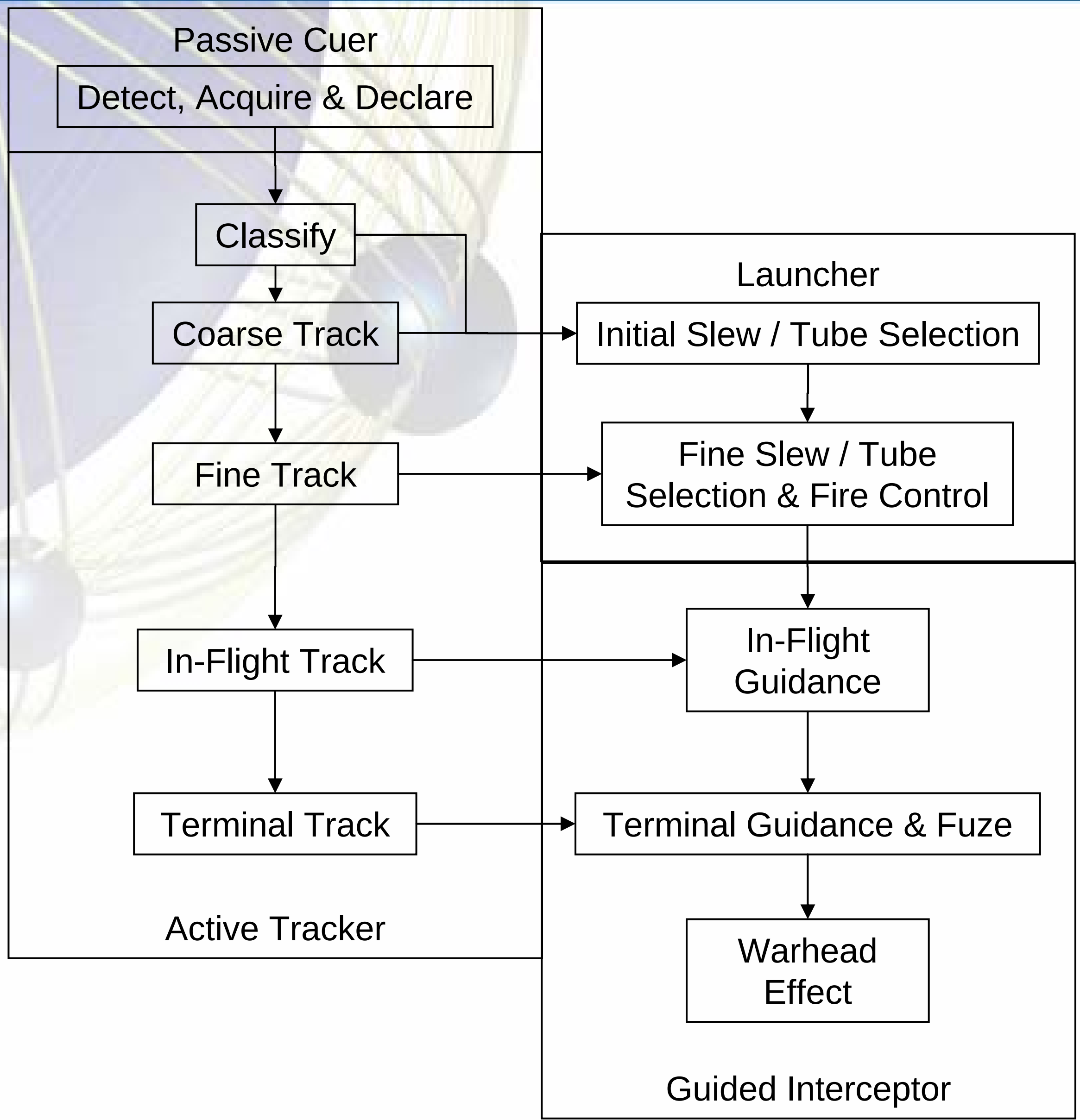
Architecture U3



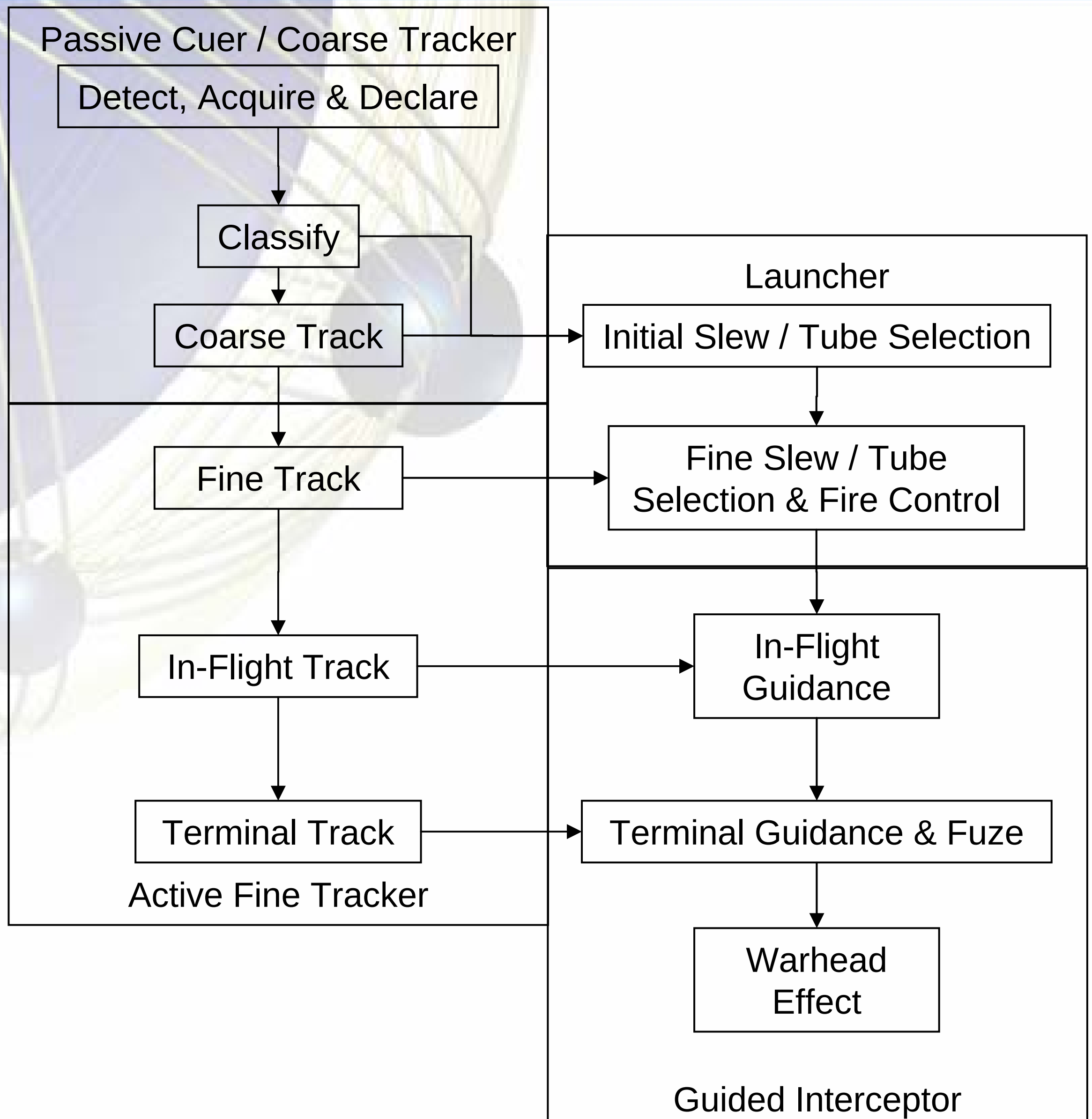
Architecture U4



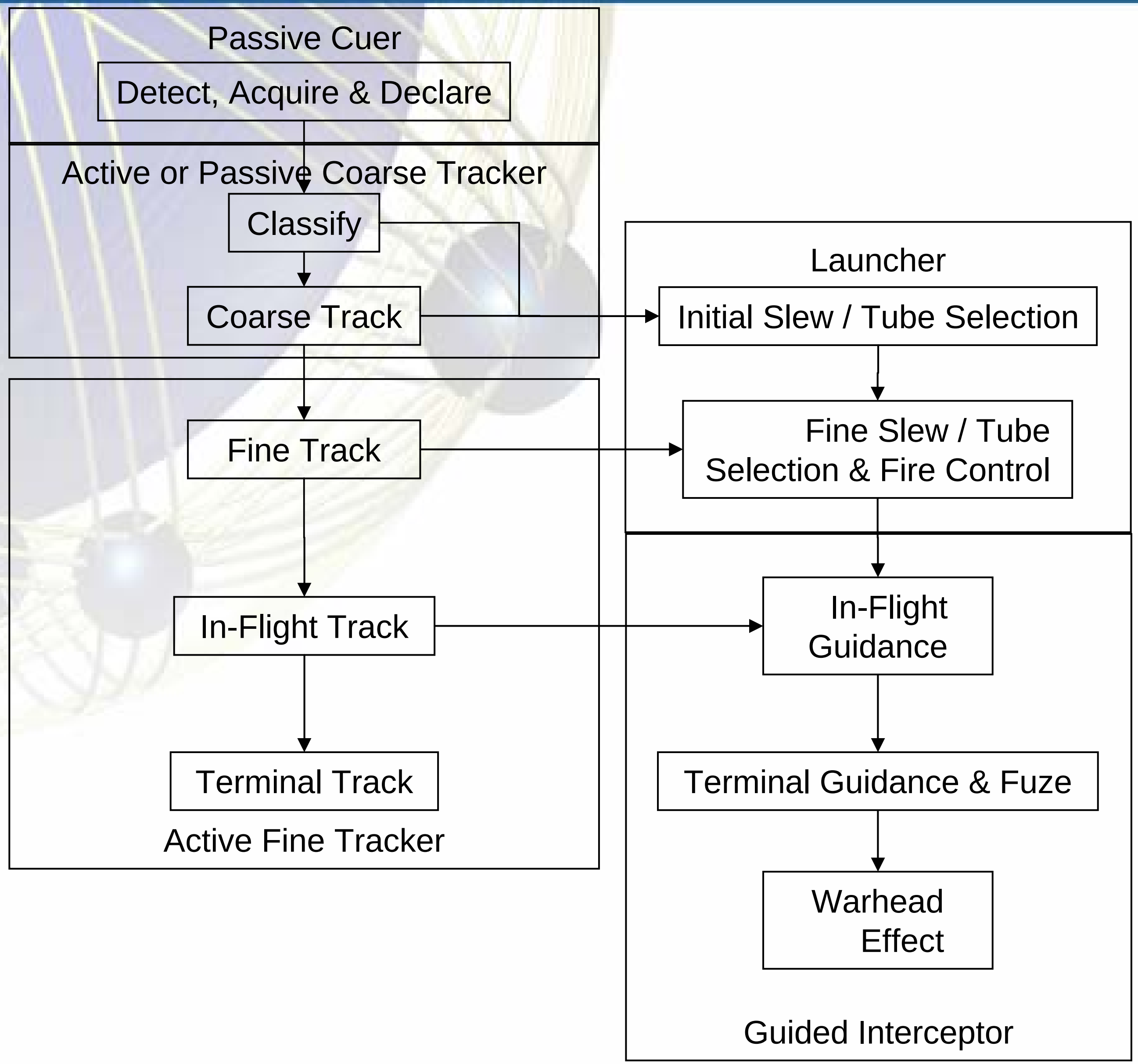
Architecture G1



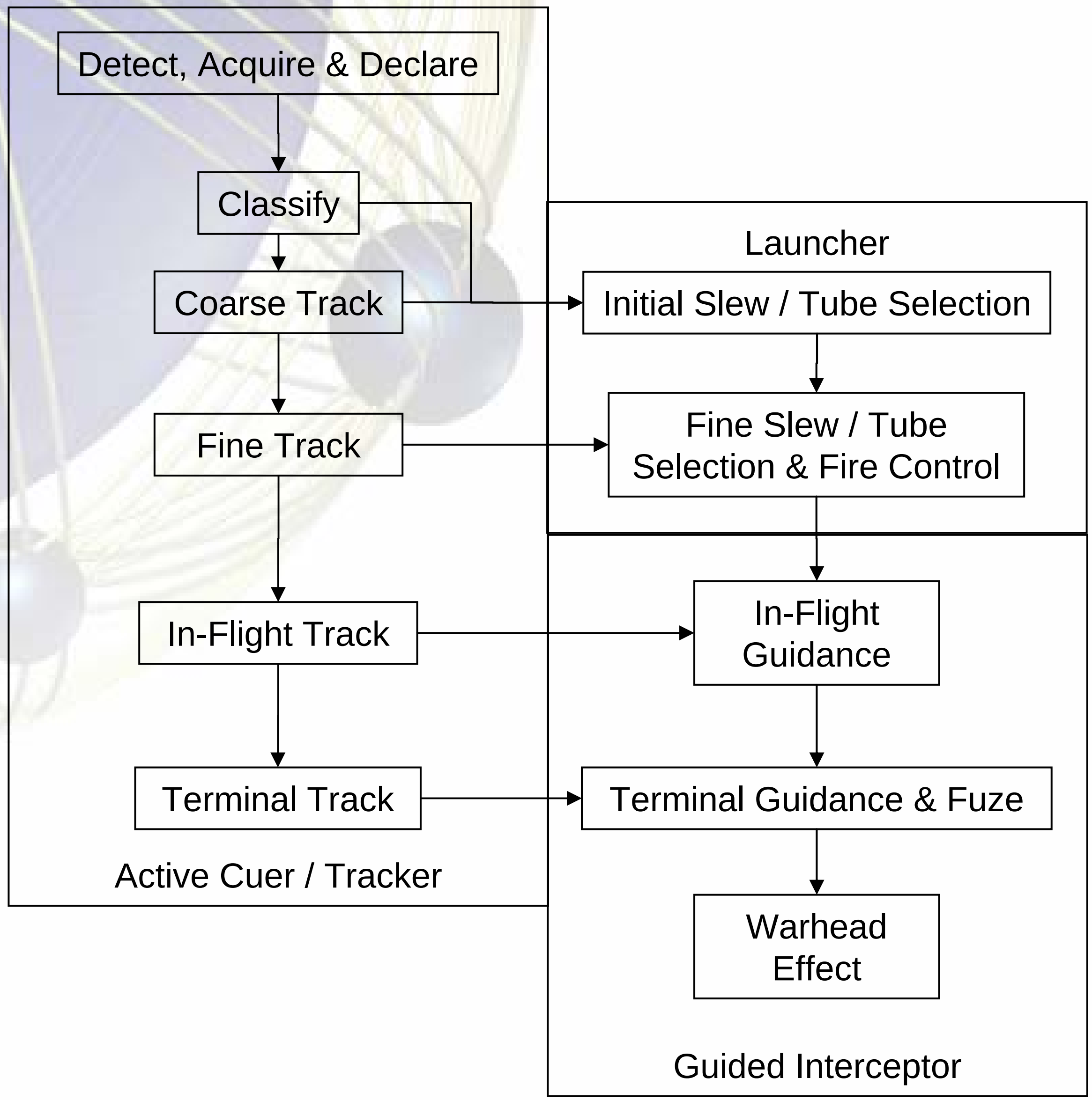
Architecture G2



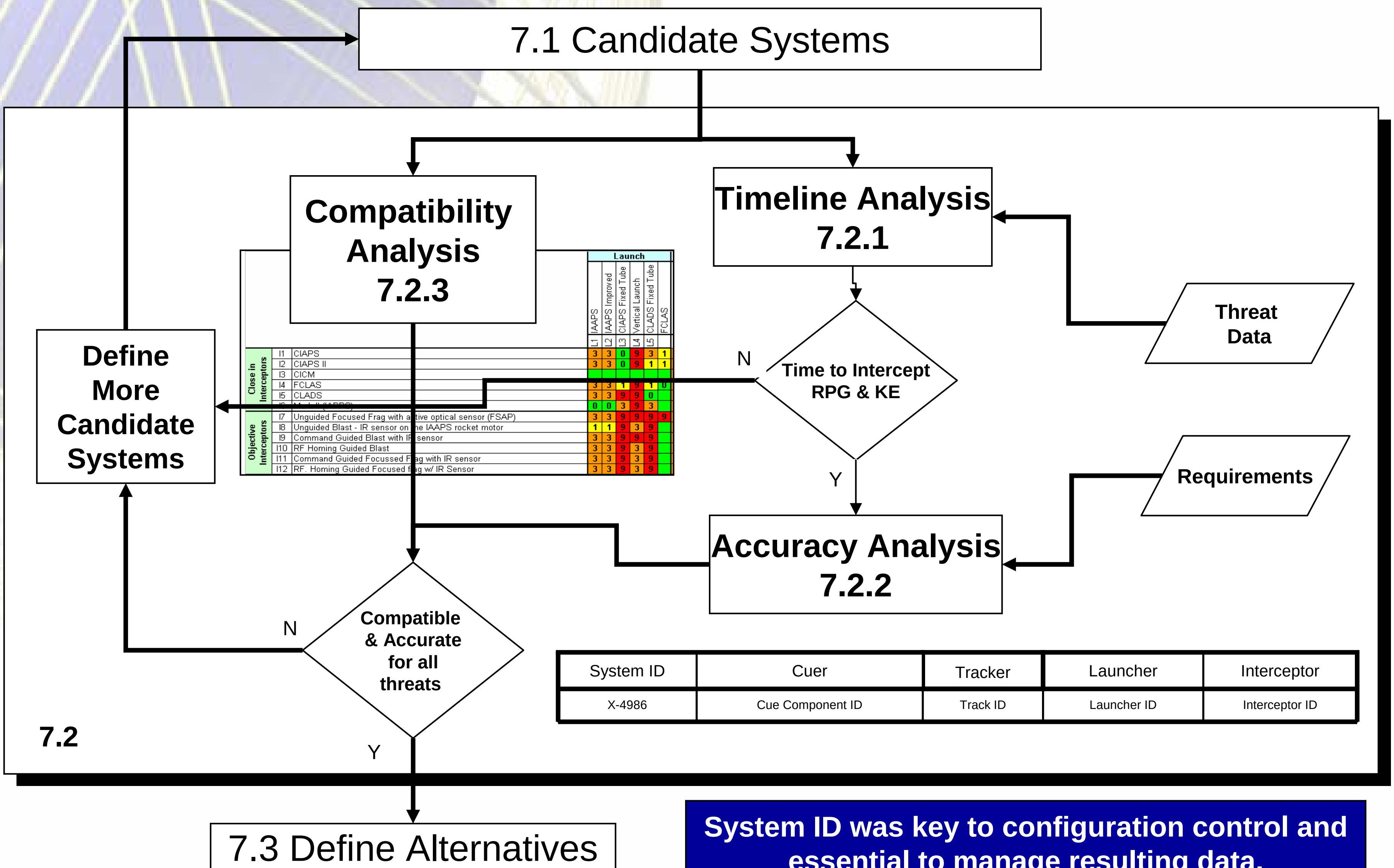
Architecture G3



Architecture G4



7.2 Evaluate Candidates

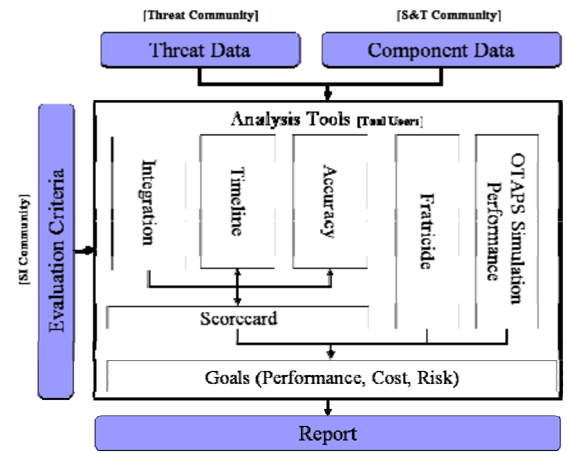


System ID was key to configuration control and essential to manage resulting data.

APS Trade Study Tool Architecture

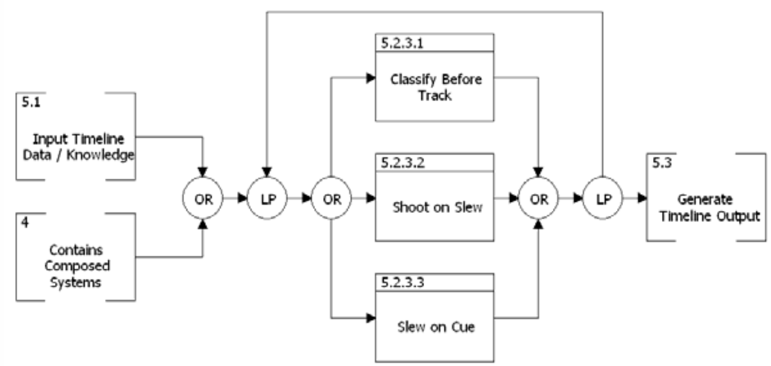
Abstract Architecture

- ❑ Schematic Block Diagrams
  - ✓ Physical Architecture
  - ✓ Interfaces

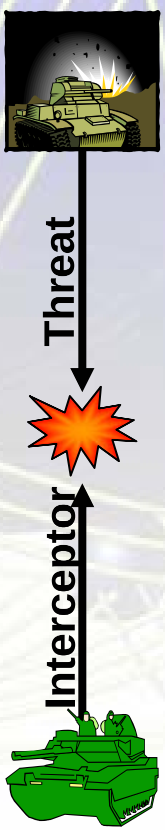


Formal Architecture

- ❑ IDEF0, FFBD, EFFBD, Hierarchy
  - ✓ Physical Architecture
  - ✓ Functional Architecture
  - ✓ Interfaces
  - ✓ Data Flow



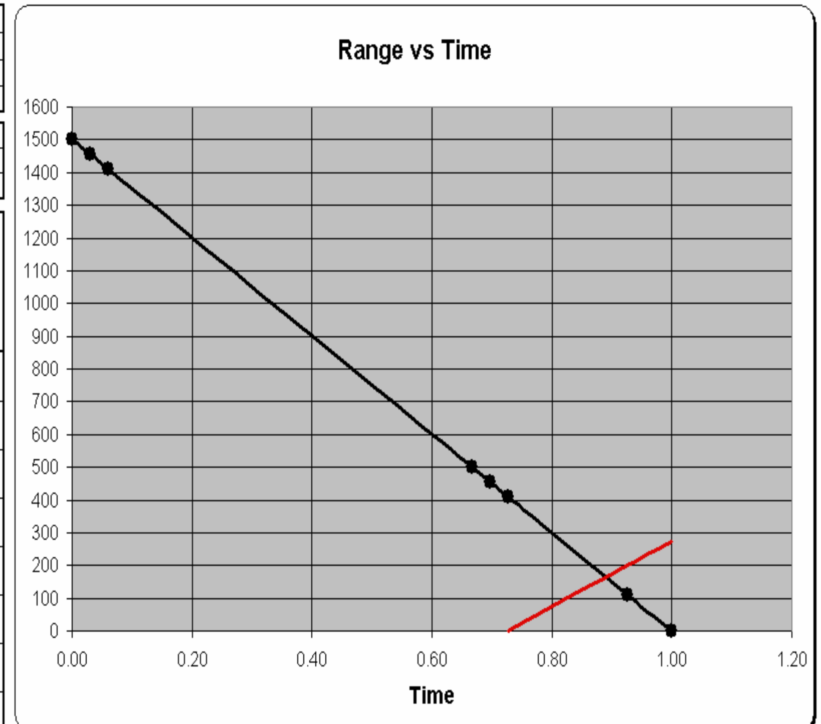
7.2.1 Timeline Analysis

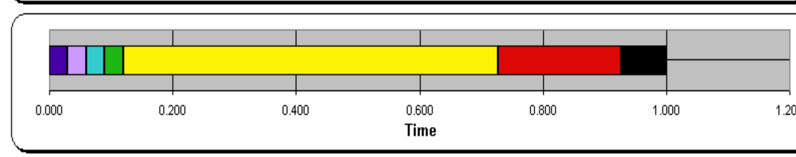


Threat	Threat Launch Range	1500.00	Meters
	Threat Average Velocity	1500.00	Meters/Second
	Time to impact Platform	1.00	Seconds
	Threat Time to Intercept Point	0.87	Seconds

Interceptor	Min Range to Defeat Threat	200.00	Meters
	Time to Min Range	0.20	Seconds
	Interceptor Average Velocity	1000.00	Meters/Second

System Functions		Function Time	Timeline	Threat Range to Platform	Interceptor Range to Threat
	Threat Launch	0.000	0.00	1500	
Cue	Cue	0.030	0.03	1455	
	Track Handoff	0.000	0.03	1455	
Track	Track Established	0.030	0.06	1410	
	Min Fire Control Time	0.000	0.06	1410	
Margin		0.607	0.67	501	
Launch	Slew	0.030	0.70	456	
	Stabilize	0.030	0.73	411	
Intercept	Initiate Interceptor	0.000	0.73	411	0
	Launch & Fly Out	0.200	0.93	111	200
	Platform Defeat	0.073	1.00	9.48E-13	273.33





Pass Screen

Timeline Analysis was a first order filter used to Identify Technology Combinations that do not have potential to achieve FCS Objective APS requirements.

7.2.3 Compatibility Analysis

SCORING INSTRUCTIONS

Level	Component Compatibility Description
9	- Significant software integration with concurrently developed hardware.
3	- Hardware and/or software interfaces defined and analyzed so complexity is
1	- Software and/or hardware interfaces known but need to be revised with as
0	- Interfaces exist and no changes are required.

Hardware interface c

- Mechanical – envelope, attachment, obscuration, alignment
- Hydraulic and pneumatic - flow rates, pressures
- Mass – weight, moments of inertia, centers of gravity
- Environment – mechanical shock and vibration, particulate, ele
- Thermal - temperature limits, temperature control
- Electrical – signals, voltage, power

Software interface considerations include added requirements for

- Data encryption and encoding
- Data structures
- Data storage
- Data transfer rates
- Data communication protocols
- Data processing and algorithms

Experties

0	No experties, Don't fill out scores for anything you have no exp
1	If you have seen a briefing on the technology or have only rece
3	If you have a working knowledge (understand underlying physic
9	If you are intimately involved in designing, developing, and or in

Cue - Track Results

Launch - Intercept Results

Launch - Intercept Compatibility Results		Launchers						
		Launcher 1	Launcher 2	Launcher 3	Launcher 4	Launcher 5	Launcher 6	Launcher 7
Interceptors	Interceptor 1	1	1	1	1		9	0
	Interceptor 2	1	0	0	3		9	1
	Interceptor 3	0	2	0	9	1	9	2
	Interceptor 4	1	1	1		1		1
	Interceptor 5	0	4	3	1		1	4
	Interceptor 6	0	4	3	1		1	4
	Interceptor 7		3	9	3	3	0	3
	Interceptor 8		3	9		3		3
	Interceptor 9		1	9	3	1	0	1
	Interceptor 10		3	9	3	3	0	3
	Interceptor 11		1	9	1	1	1	1
	Interceptor 12		1	9	1	1	1	1
	Interceptor 13	0	9	9		0		3

Compatibility Analysis was used to determine if the Technology Combinations interfaces were compatible and could realistically be combined to form a system.

7.3 Define Alternatives

7.2 Evaluate Candidates

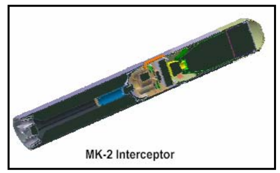
Define System Configuration 7.3.1

Define Alternative Architecture 7.3.2

Define Principle of Operation 7.3.3

5.3

System ID	Cuer	Tracker	Launcher	Interceptor
A-4986	**Cuer 04**	**Tracker 09**	**Launcher 08**	**Interceptor 06**



Principle of Operations

1 of 8 Physical Architectures

Cooled Single Color IR

Detect, Acquire & Declare

Classify

Coarse Track

Fine Track

W-Band Tracker

In-Flight Track (No-Op)

Terminal Track (No-Op)

360 Hemi Slewed Launcher

Initial Slew

Fine Slew & Fire Control

In-Flight Guidance (No-Op)

Terminal Guidance (No-Op) & Fuze

Warhead Effect

Unguided, Mark II, Command Fuze Interceptor

8.0 Evaluate / Score Alternatives

Capture Design Details of each system that passes the timeline and accuracy analysis.

7.0 Identify & Define Alternatives

- List Systems/Components
- Previous Trades
- Component Data
- Requirements

- Existing Systems
- Analysis Method,Tools
- System Assumptions

- System Alternatives
- System ID

4 → Candidate Systems 7.1 → Evaluate Candidates 7.2 → Define Alternatives 7.3 → 8

- Integrate System Candidates
- Organize Component Data
- ID Functional Architectures

•Analyze System Candidate Potential
  - Timeline
  - Accuracy
  - Component Compatibility

Reach Consensus

System and Technology Architectures Required!!!!!

8.0 Score APS(s) Alternatives

Measure how well each of the systems meets the Goals!

7.0 Identify & Define Alternatives

GRA RDECOM Gleason Simulations
When GRA Is Not Available Use
Spreadsheet Analysis

CASRED Model

Trade Study Goal Analysis Calculators/Tools

Analyze & Publish Report

"Validated" Component Technology Data

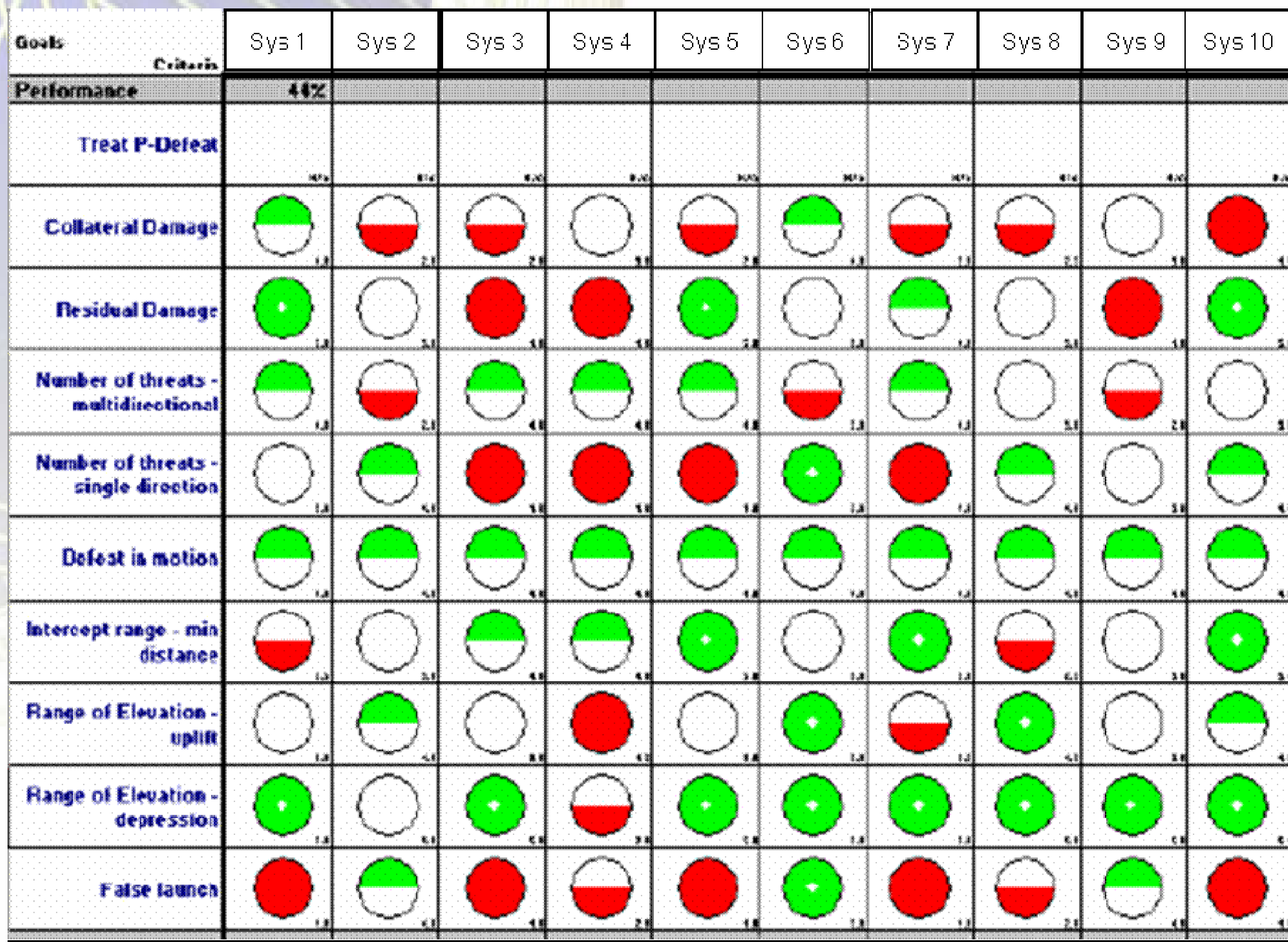
Goal 1*
Pp (Threat 1)
Pp (Threat 2)
Pp (Threat 3)

Goal 2
Max. Fratricide & Collateral Damage Control

Goal 3 - 6
Max Operability
Min Interface Needs
Min Schedule Risk
Minimize Cost

Trade Study Leverages Models/Simulations

9.0 Performance Values/Utility



Summary

- Using the program requirements to derive the evaluation criteria made the trade study results traceable to user needs.
- Involving all stakeholders early and often allowed for acceptable end results.
- Establishing a System ID scheme was key to configuration control and essential to manage resulting data.
- Capturing System Architectures was essential to understand how to model system time function and communicate it to the community.
- Tool Architecture helped to communicate how each tool was used in the trade study process.
- As a result of capturing the tool architecture
  - ✓ many tool interface gaps were identified and fixed.
  - ✓ The Schematic Block diagram was updated to be more correct.
- Tool Architecture was valuable to communicate with each tool developer interfaces
- Modeling and Simulation was a key player in conducting the APS Trade Study and helped to drive decisions. This study could not be don’t without using models.
- Using a defined process were all stakeholders were involved and had a voice yielded results the community could accept.

The Systems Engineering Process was instrumental to the success of the APS Trade Study.

BACKUP SLIDES

APS Trade Study Tool Architecture

Abstract Architecture

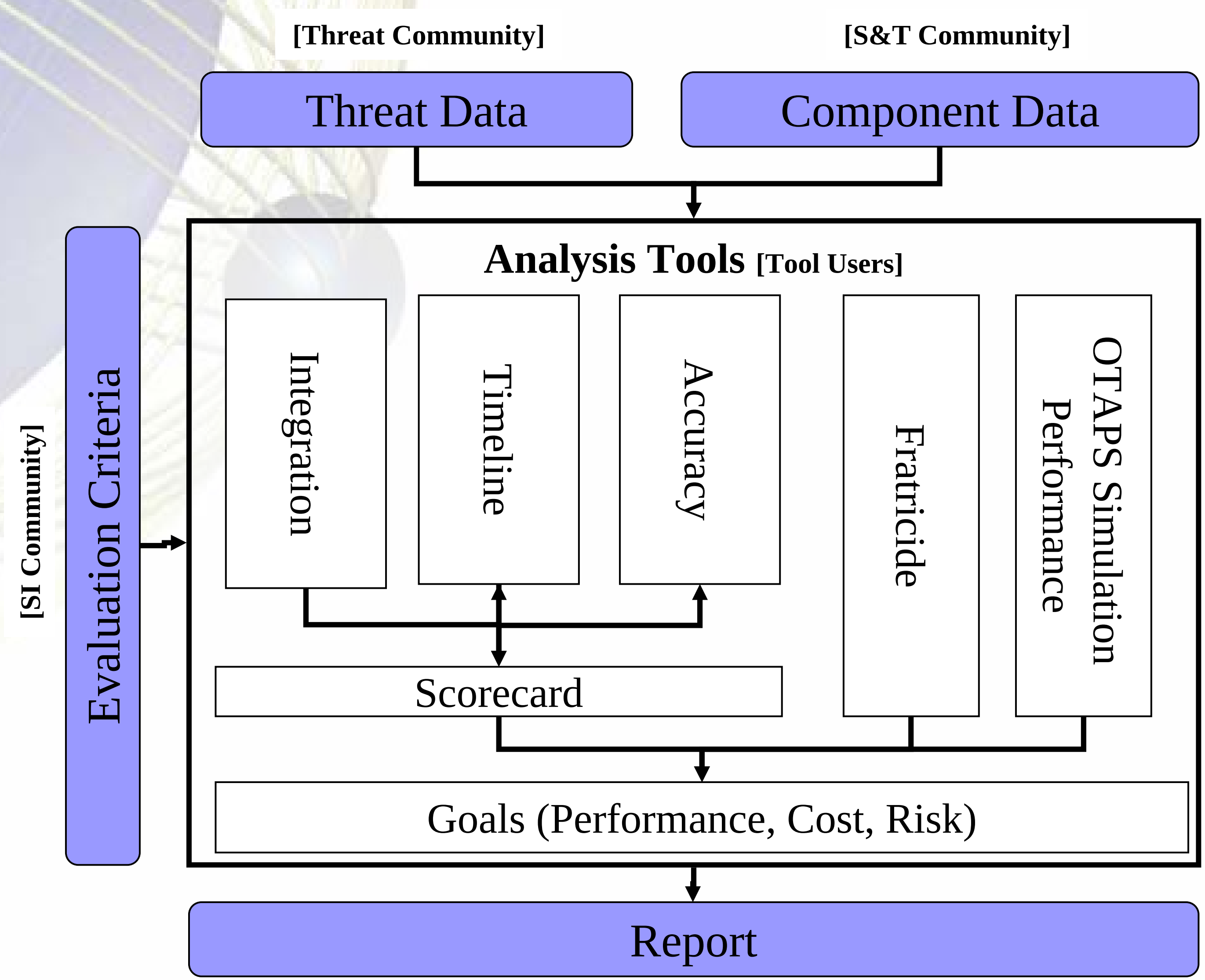
- Schematic Block Diagrams
  - Physical Architecture
  - Interfaces

Formal Architecture

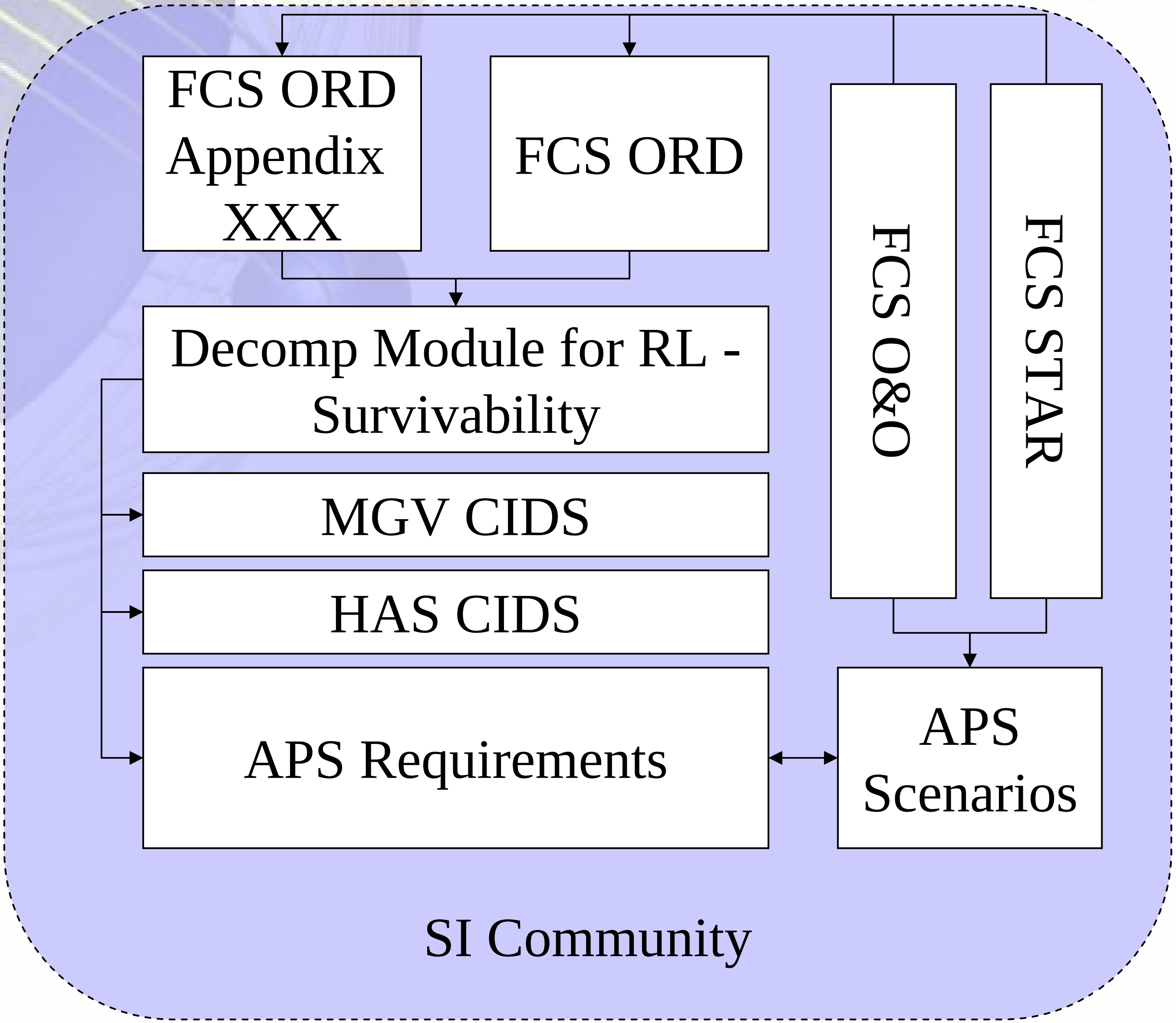
- IDEF0, FFBD, EFFBD, Hierarchy

Home
Threat Data
Component Data
Evaluation Criteria
Timeline
Accuracy
Integration
Fratricide
OTAPS Simulation
Scorecard
Goal
Report

Schematic Block Diagram



Evaluation Criteria



Component Data

Component Architecture

- Physical
- Functional

Component Characteristics

- Performance
- Operational
- Physical
- Environmental

Component Risk

- Technical
- Program

S&T Community

Threat Data

Threat Description

Size and Weight

Signature Characteristics

Material Characteristics

Performance

Operational Tactics

FCS STAR

Threat Community

Home
Threat Data
Component Data
Evaluation Criteria
Timeline
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OTAPS Simulation
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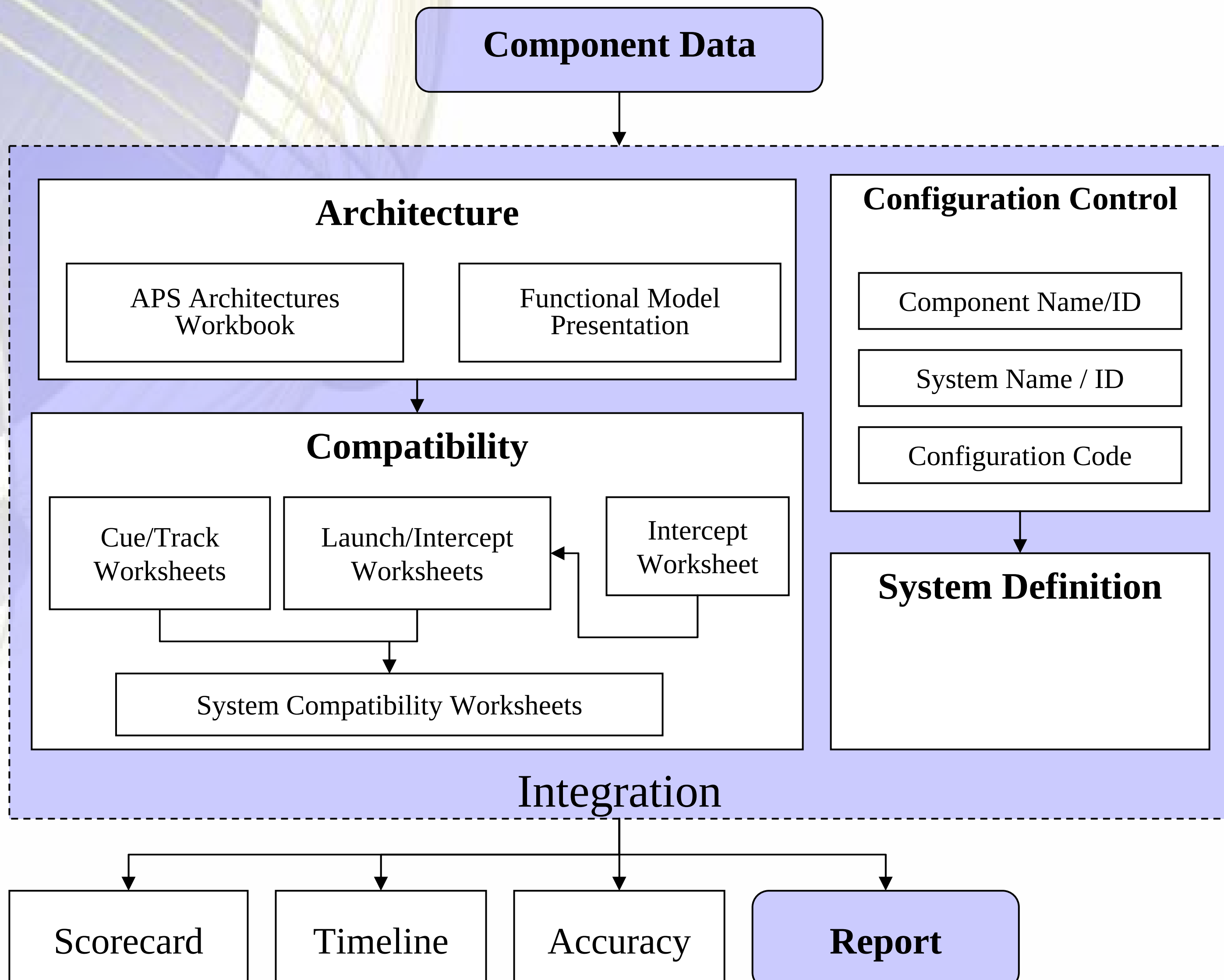
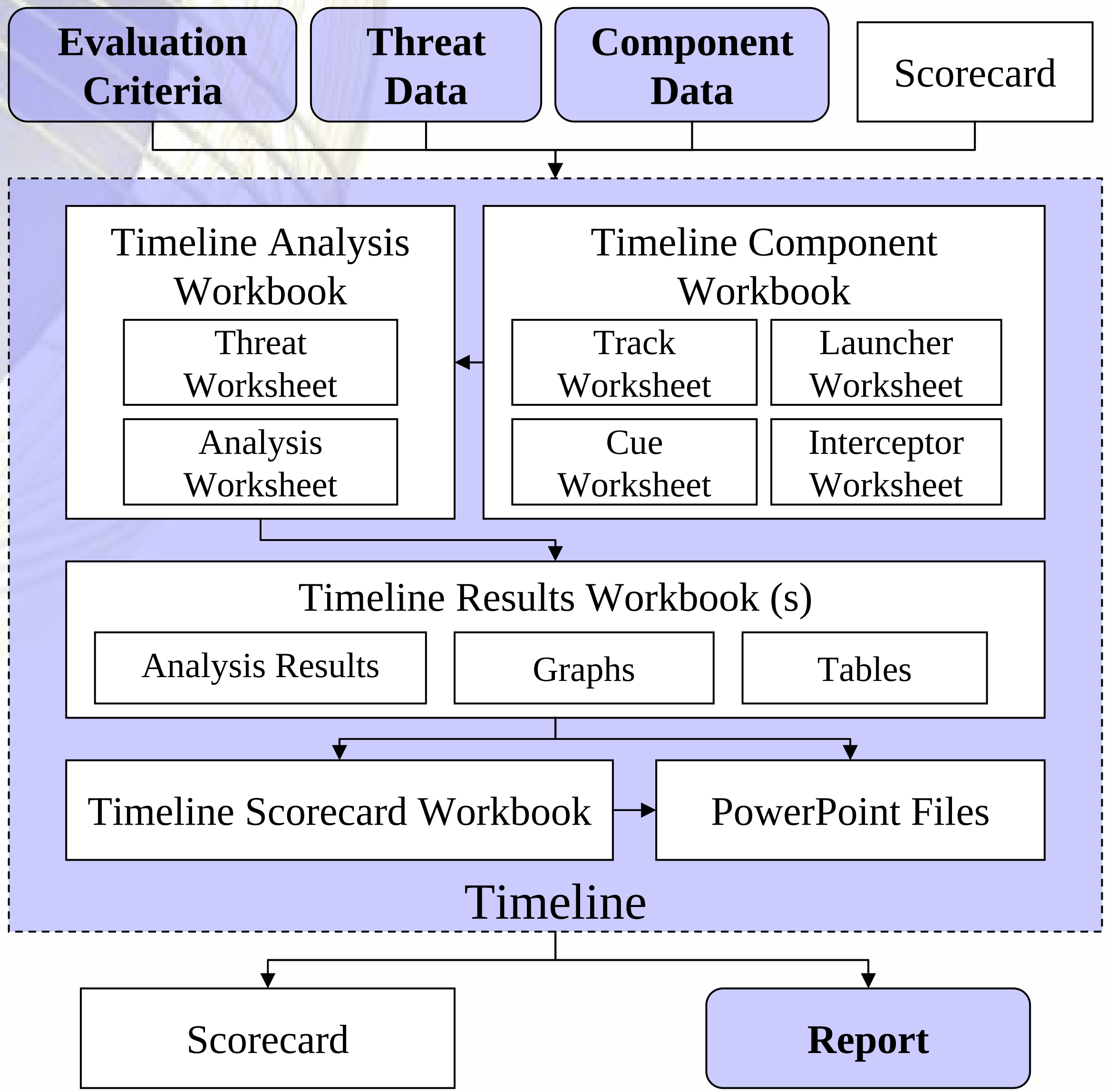
Report

Integration

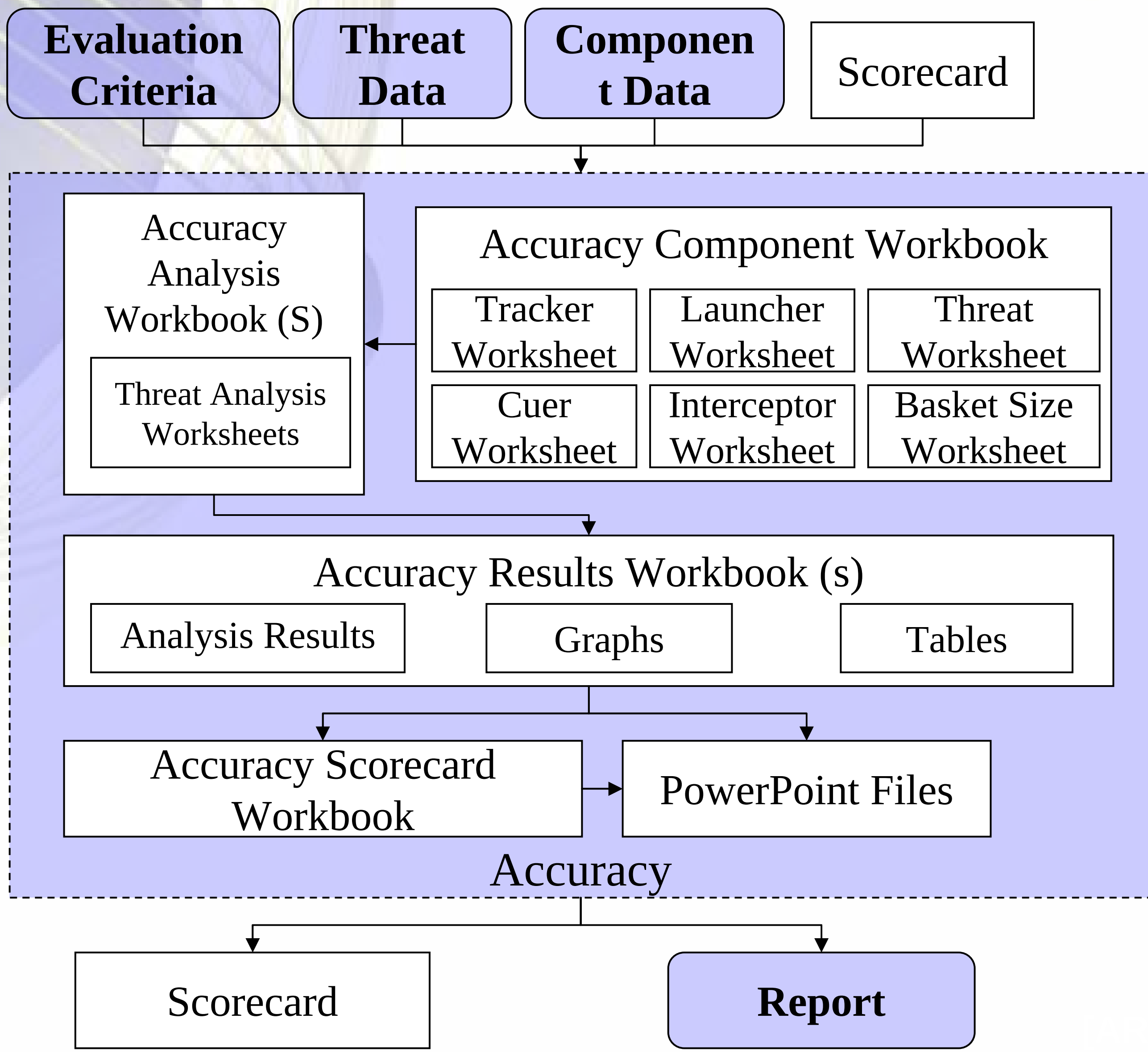


Home
Threat Data
Component Data
Evaluation Criteria
Timeline
Accuracy
Integration
Fratricide
OTAPS Simulation
Scorecard
Goal
Report

Timeline



Accuracy


Evaluation Criteria
Threat Data
Component Data
Scorecard
Accuracy Analysis Workbook (S)
Threat Analysis Worksheets
Accuracy Component Workbook
Tracker Worksheet
Launcher Worksheet
Threat Worksheet
Cuer Worksheet
Interceptor Worksheet
Basket Size Worksheet
Accuracy Results Workbook (s)
Analysis Results
Graphs
Tables
Accuracy Scorecard Workbook
PowerPoint Files
Accuracy
Scorecard
Report

Home
Threat Data
Component Data
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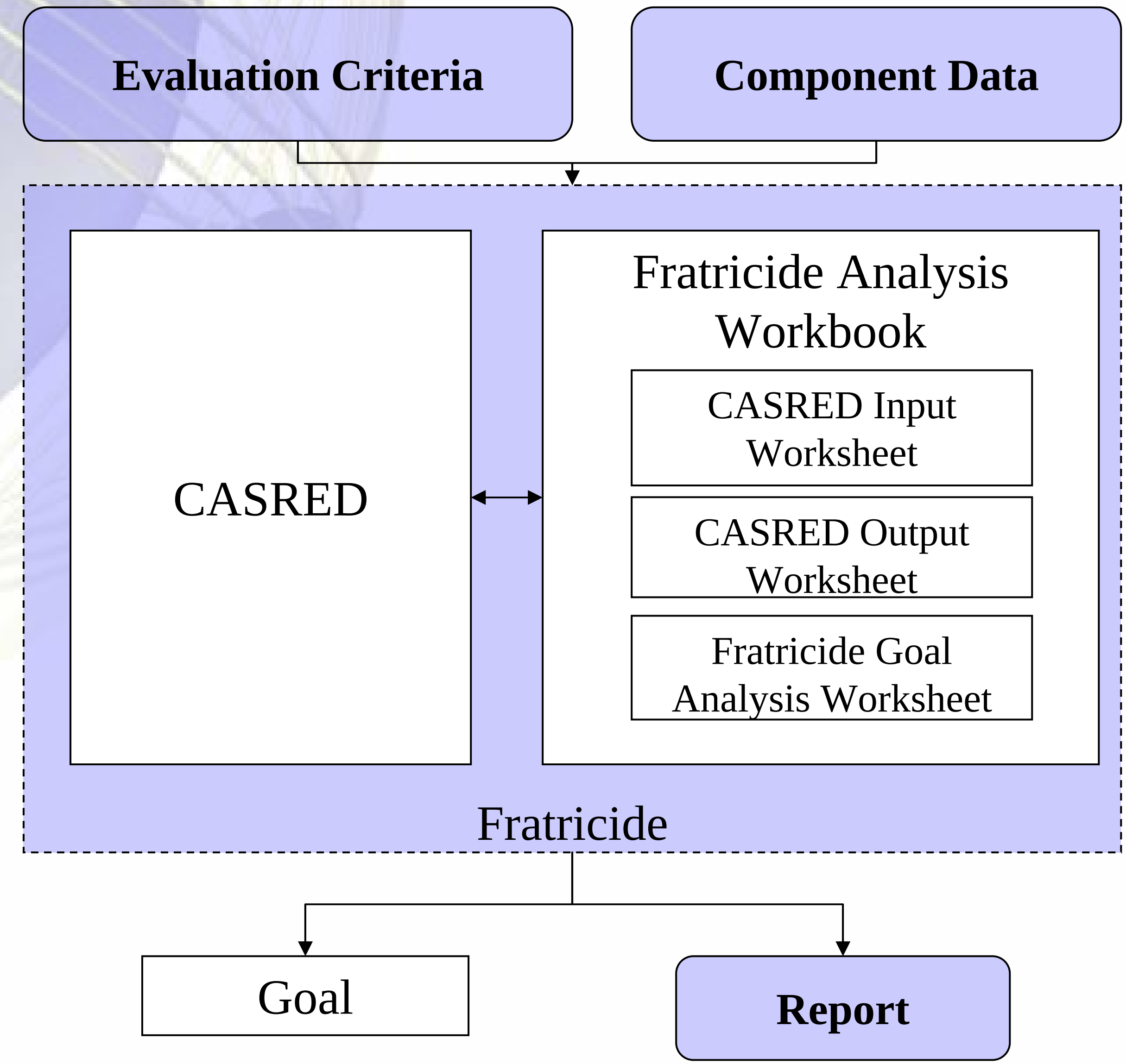
Timeline
Accuracy
Integration
Fratricide
OTAPS Simulation
Scorecard
Goal
Report

Fratricide



Home
Threat Data
Component Data
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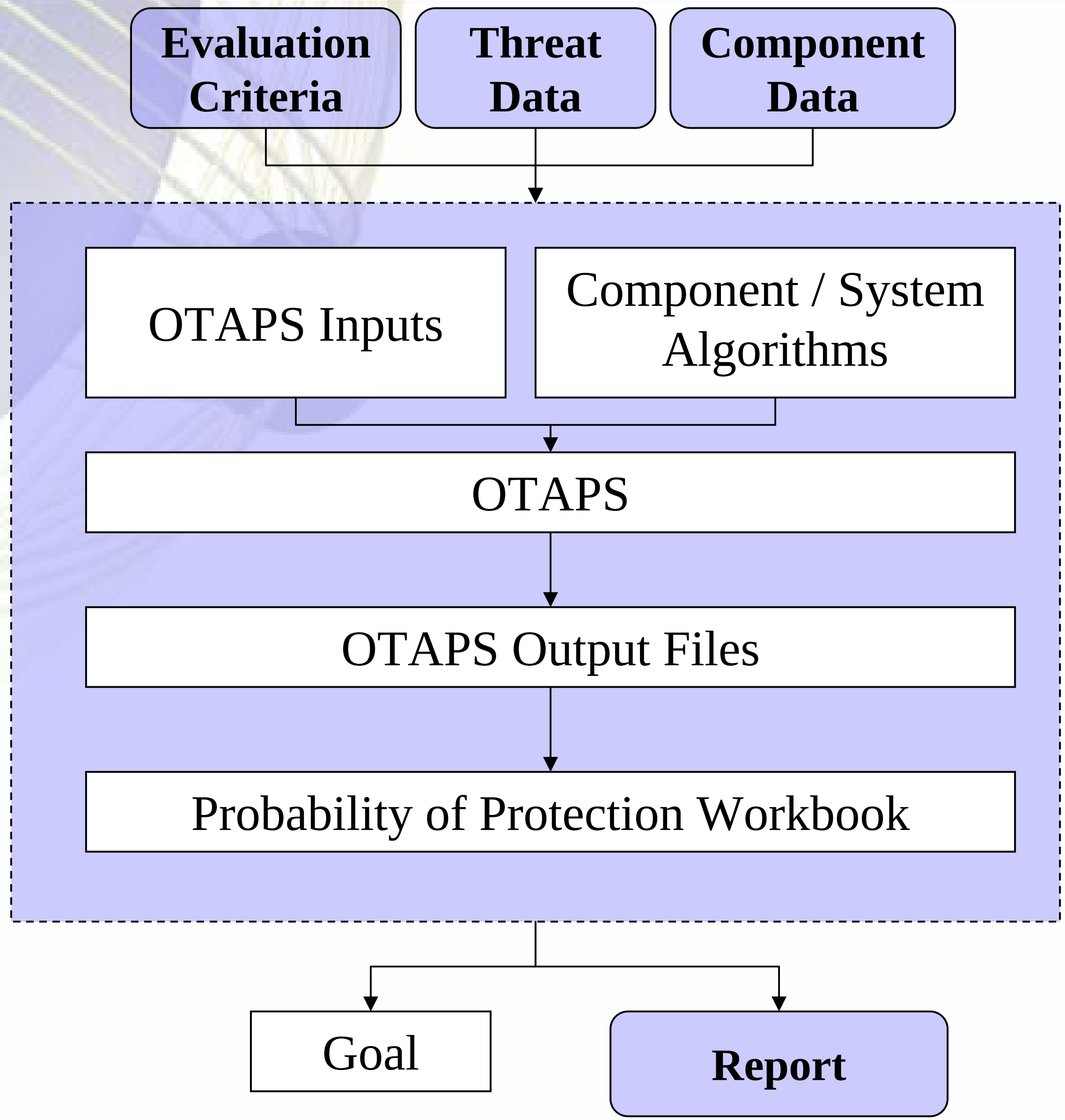
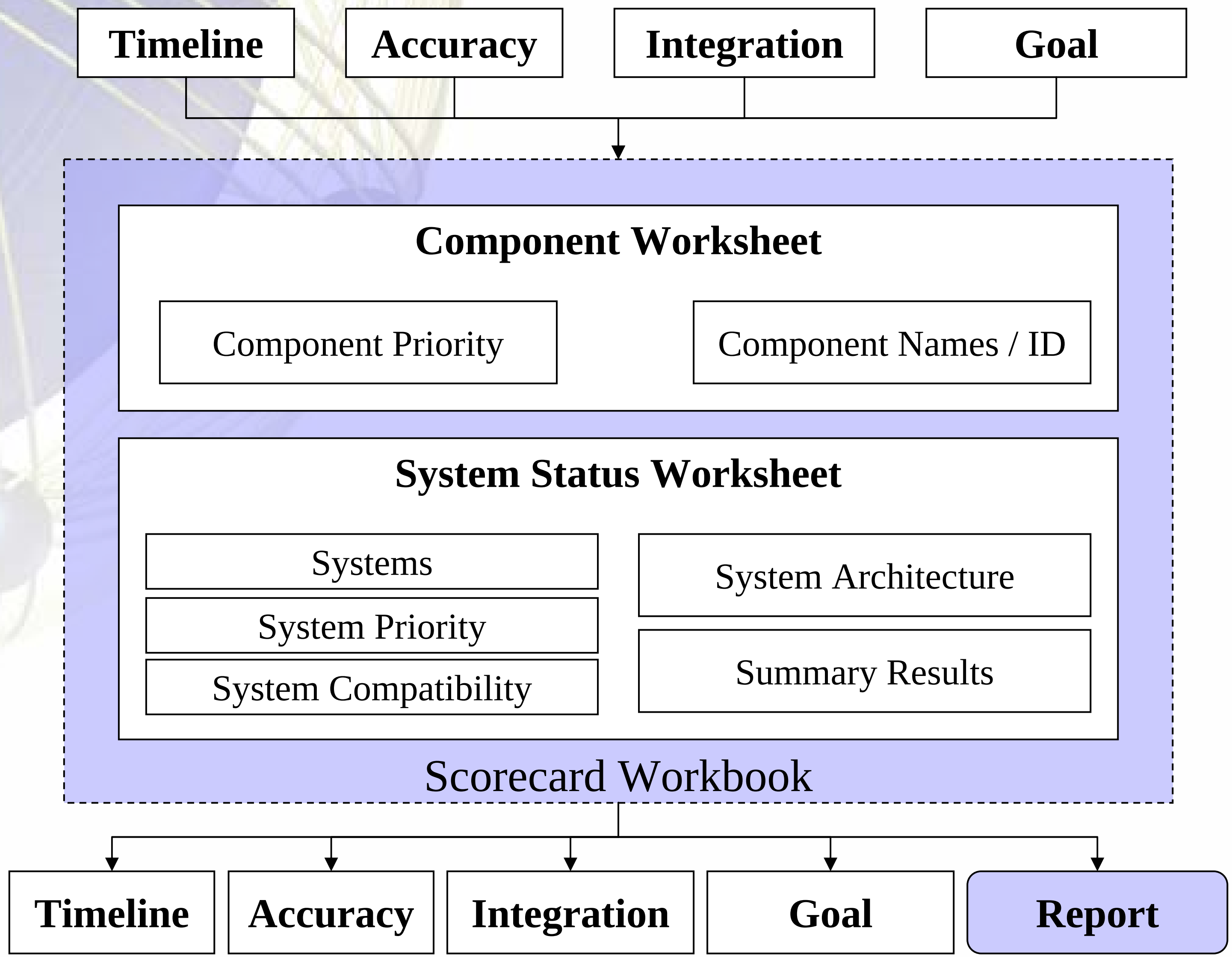
Goal
Report

OTAPS Simulation

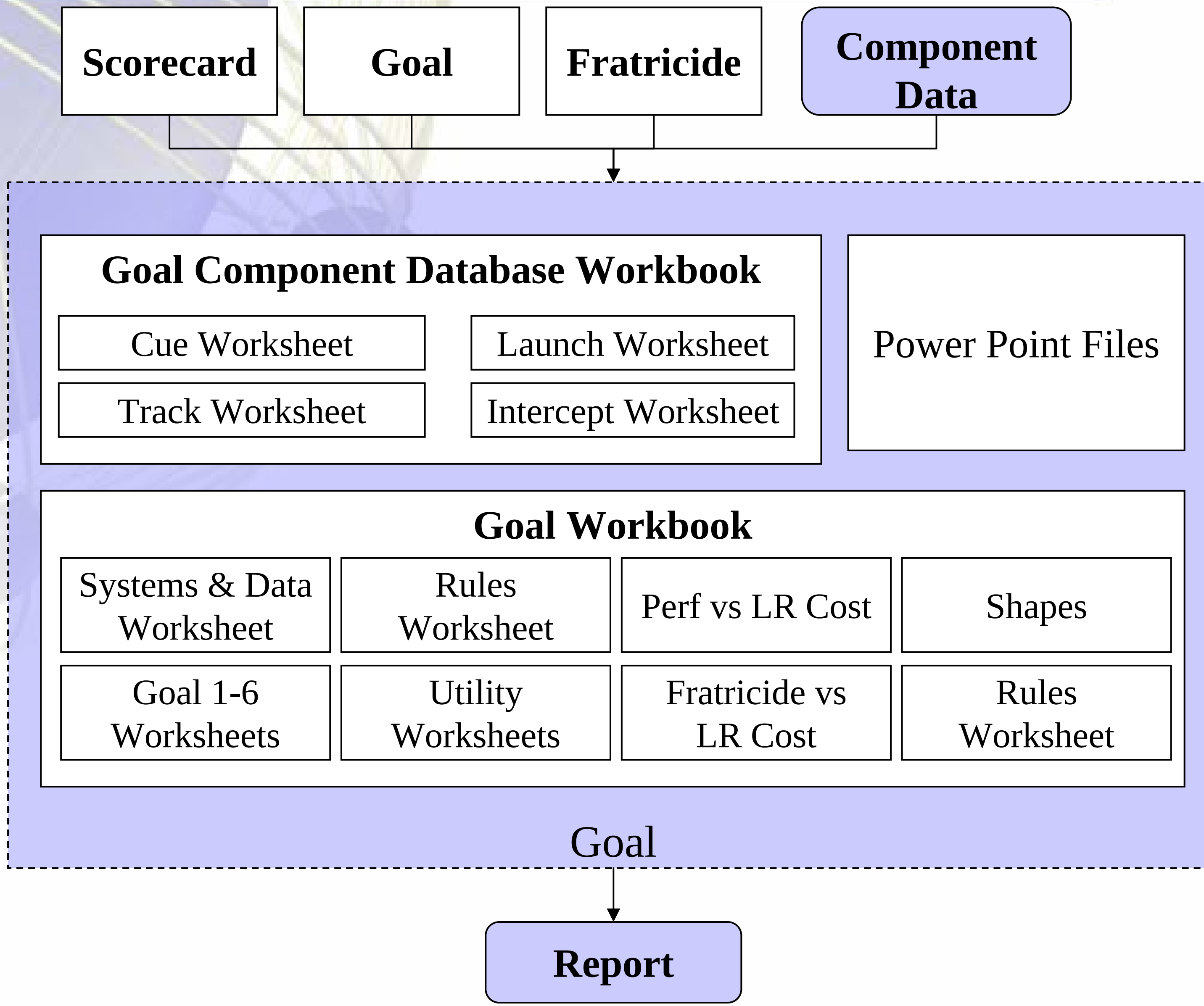


Scorecard


Timeline
Accuracy
Integration
Goal
Component Worksheet
Component Priority
Component Names / ID
System Status Worksheet
Systems
System Priority
System Compatibility
System Architecture
Summary Results
Scorecard Workbook
Timeline
Accuracy
Integration
Goal
Report

- Home
- Threat Data
- Component Data
- Evaluation Criteria
- Timeline
- Accuracy
- Integration
- Fratricide
- OTAPS Simulation
- Scorecard
- Goal
- Report

Goal



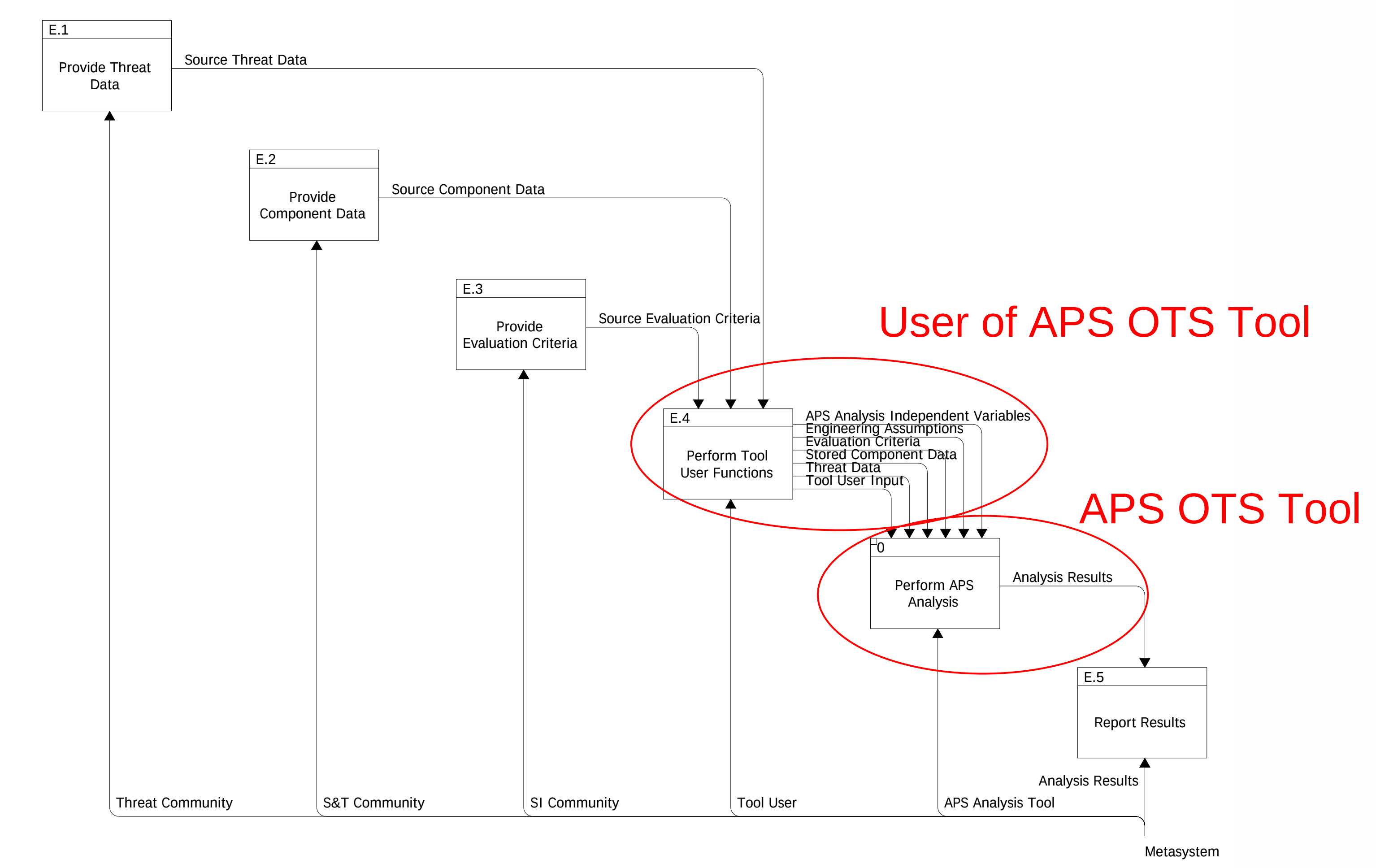
Report

- Accuracy Analysis Results
- Timeline Analysis Results
- Fratricide Analysis Results
- Systems Traded
- Component Traded
- Architectures Traded
- Threats Evaluated
- Evaluation Criteria
- OTAPS Results
- Goal Results
- Insights

APS Trade Study Tool Architecture

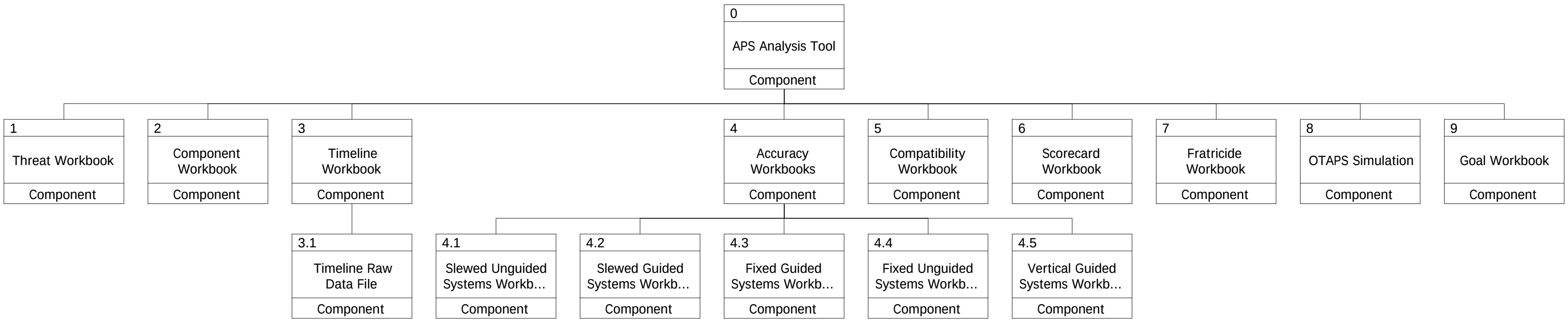
Core Architecture Model

Analysis Tool Context Diagram IDEF0



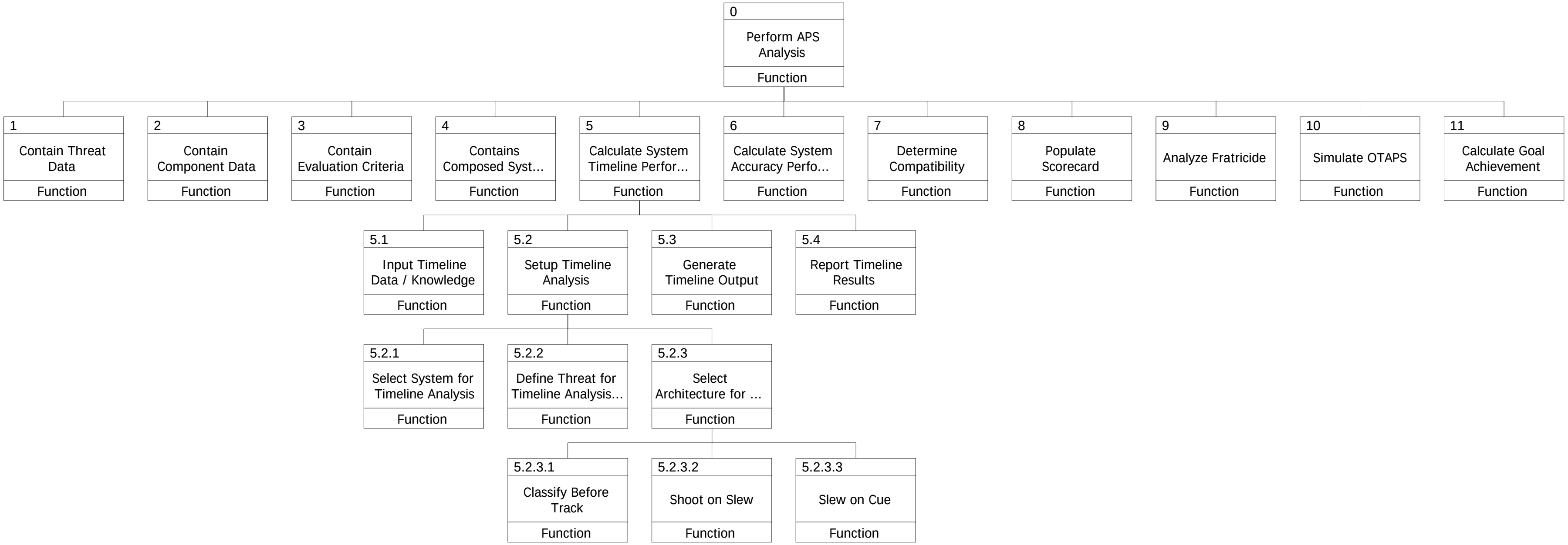
The context diagram shows the information interactions of the APS OTS Tool with the external system functions with which it interfaces

APS Analysis Tool Hierarchy Diagram



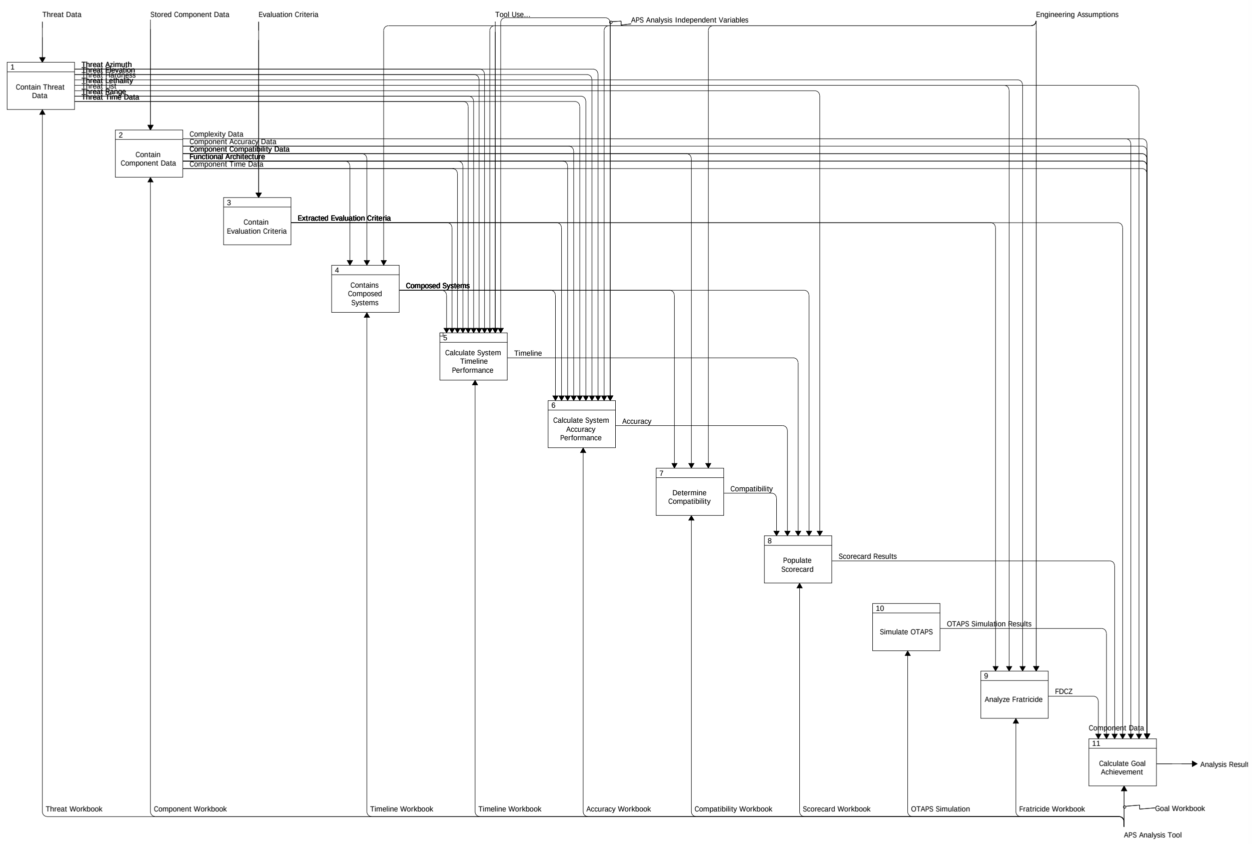
The Hierarchy Diagram was a quick way to quickly capture all the Trade Study Tools and their Hierarchical relationships. These ultimately became the configuration items that were kept under version control.

Perform APS Analysis Function Hierarchy Diagram



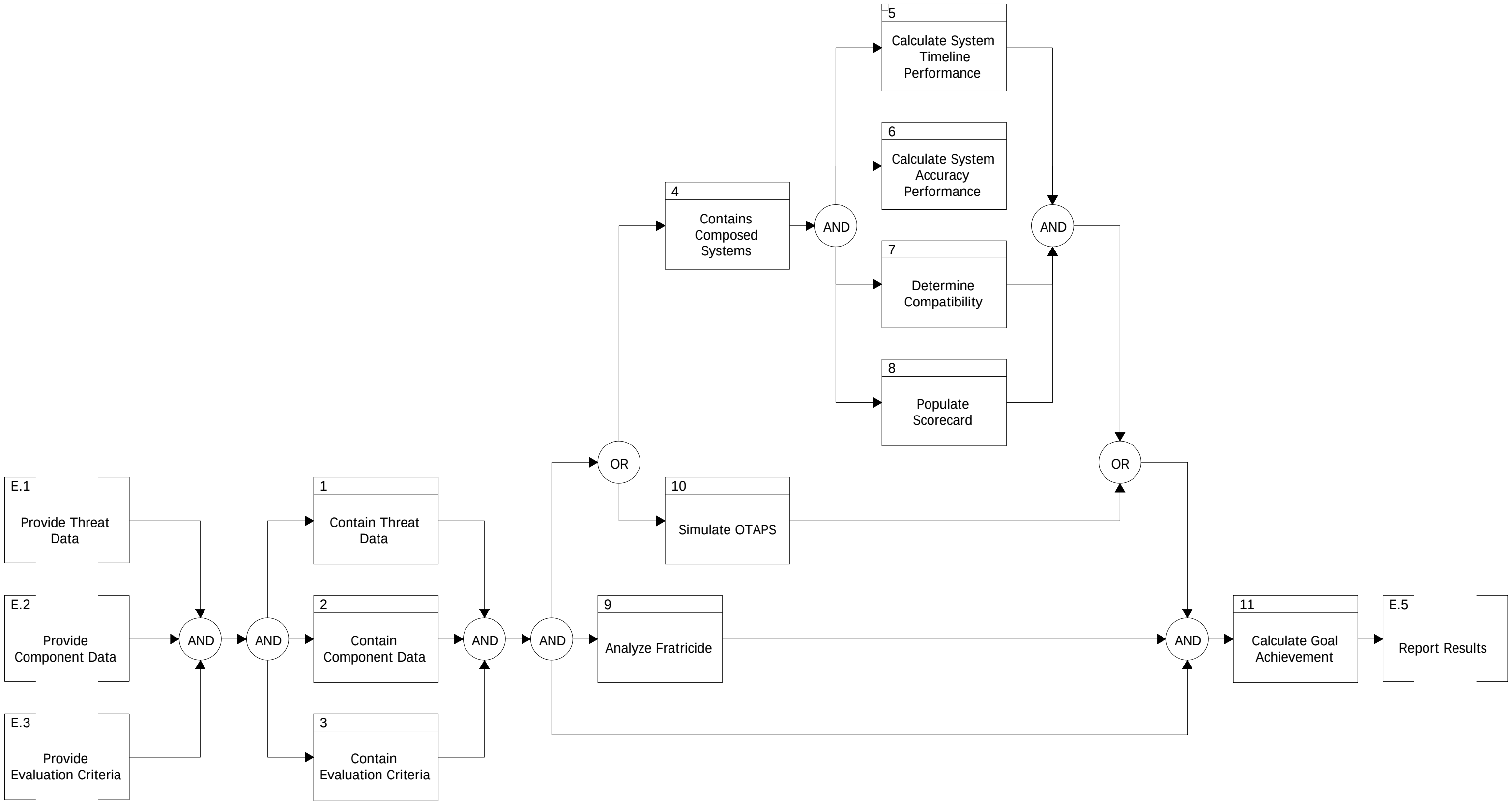
The functional hierarchy diagram emerged from the architecting process as a functional decomposition of the trade study analysis effort.

Perform APS Analysis IDEF0



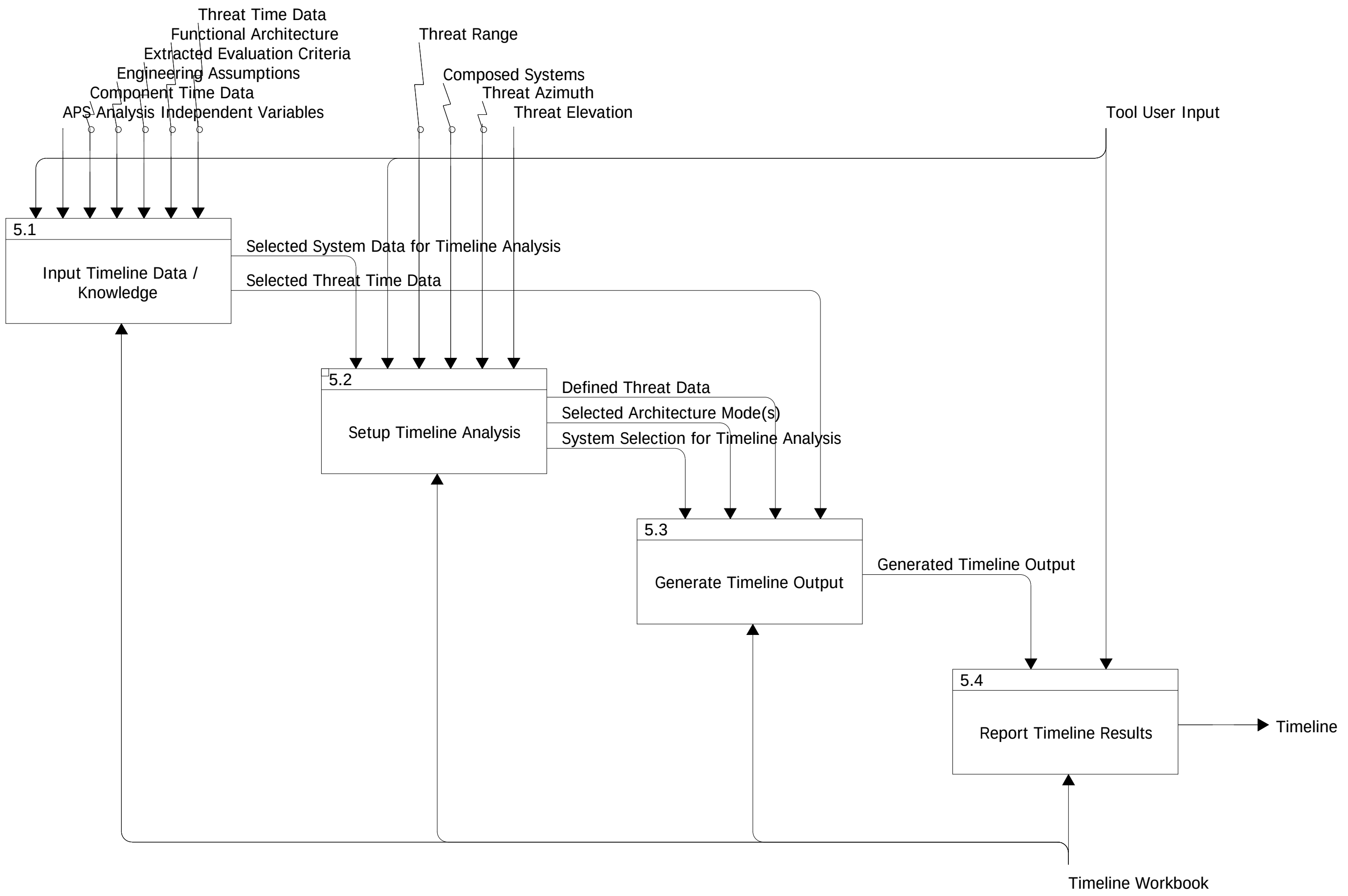
The IDEF0 diagram of the APS Tool shows both external and internal information interactions between functions and the components performing functions

Perform APS Analysis FFBD



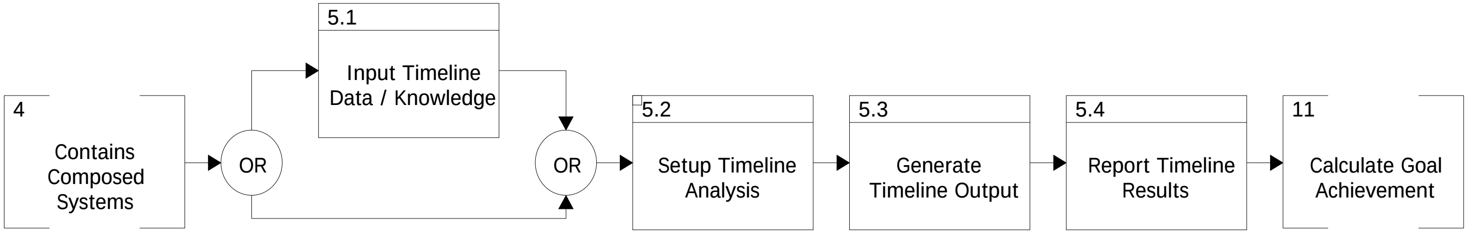
The FFBD (Function Flow Block Diagram) of the APS Tool shows the sequencing and control flow of the functions of the Tool

Calculate System Timeline Performance IDEF0

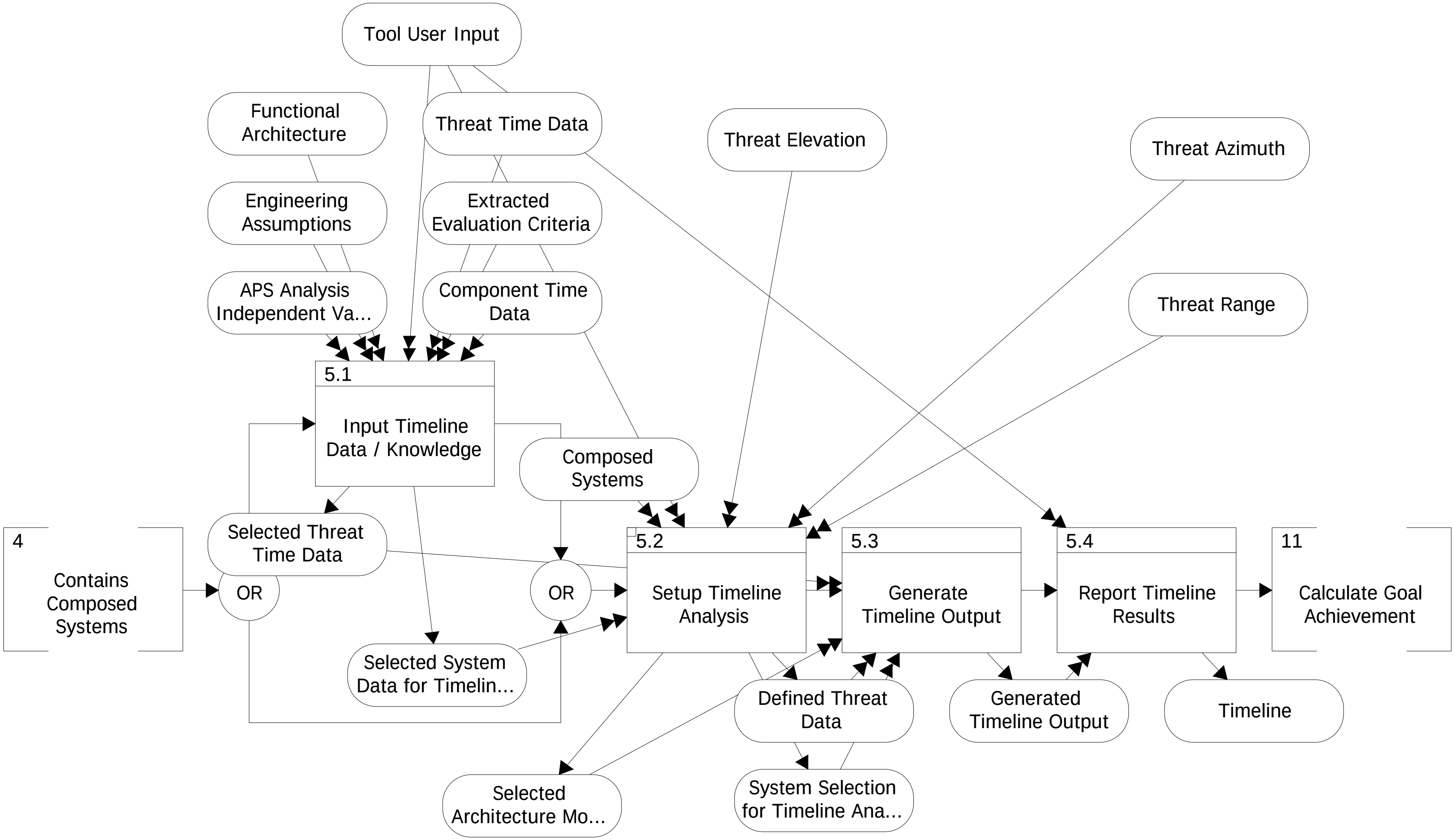


The IDEF0 proved to be a rigorous analysis of each tools inputs and outputs. The process of building this diagram resulting in discovering several tool interface issues that we had to go back and fix.

Calculate System Timeline Performance FFBD

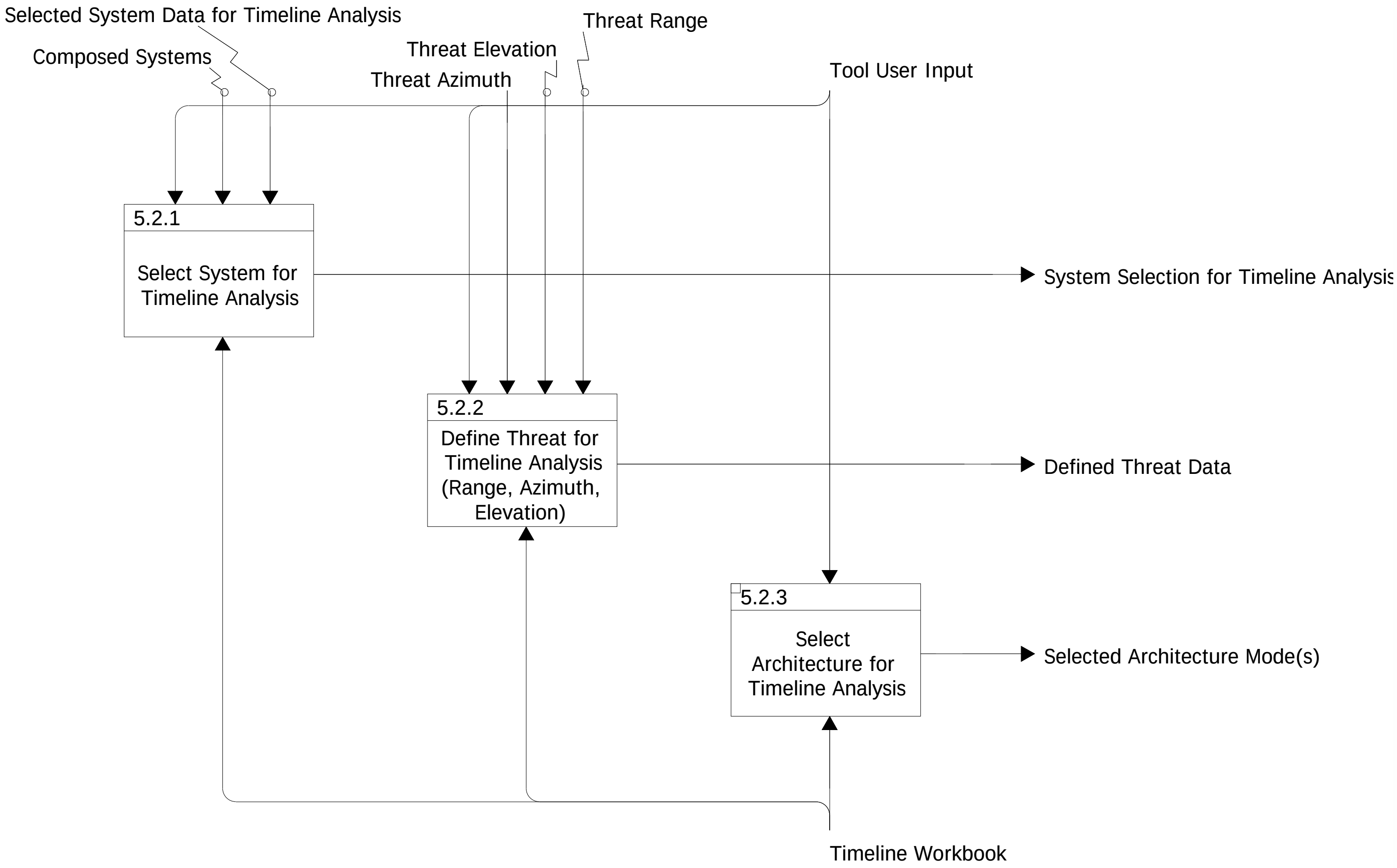


Calculate System Timeline Performance EFFBD

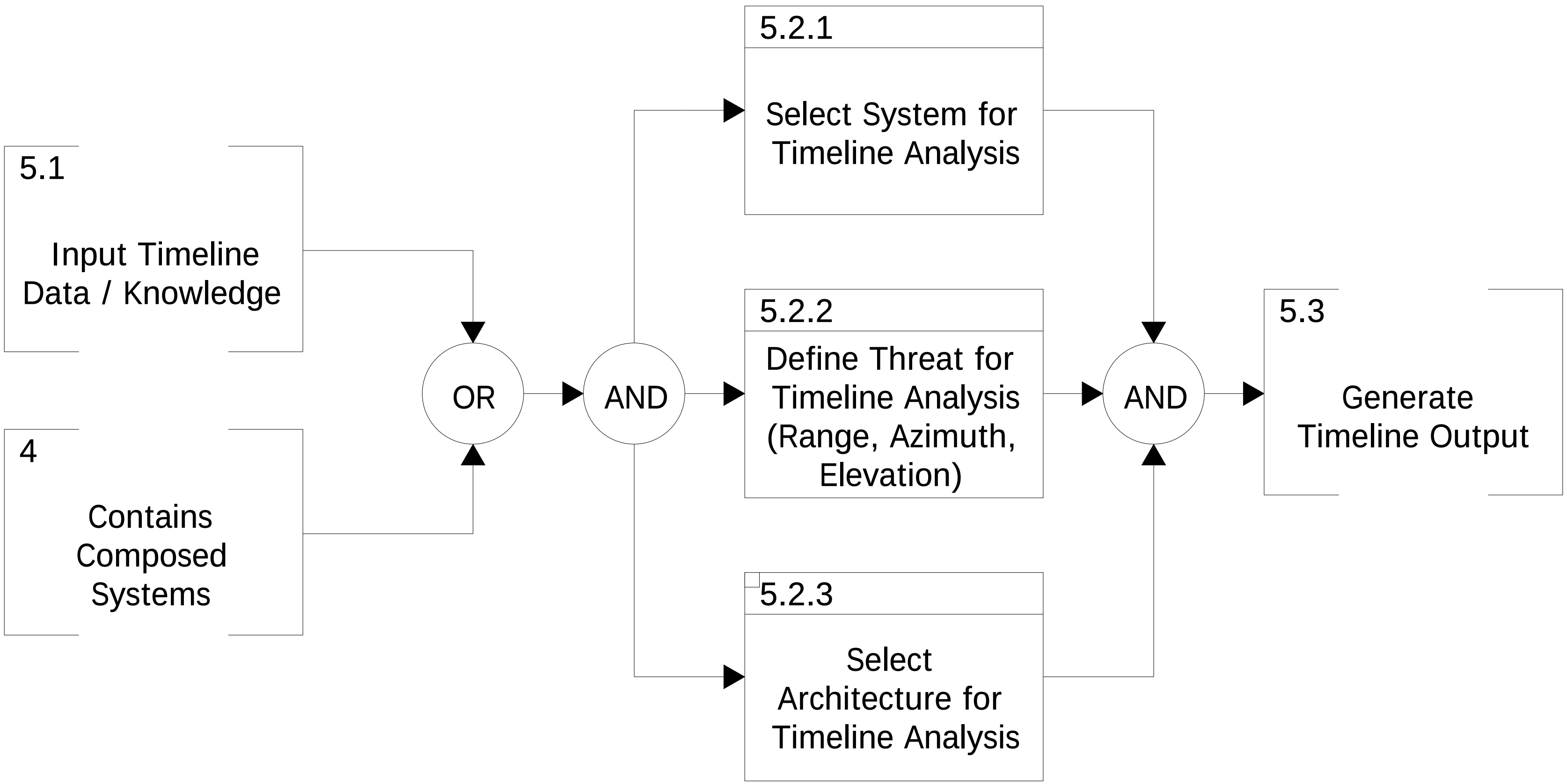


The EFFBD (Enhanced Function Flow Block Diagram) of the APS Tool shows both the data flow and control flow of the Tool

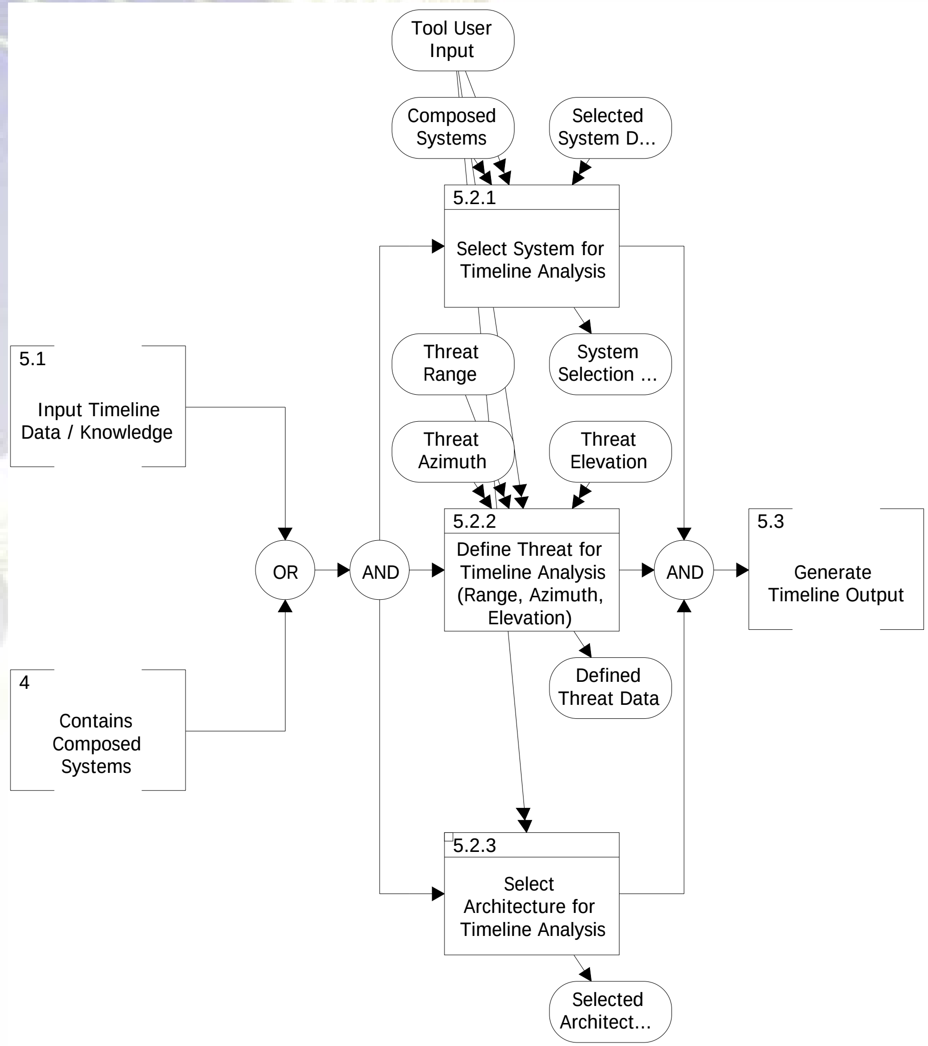
Setup Timeline Analysis IDEF0



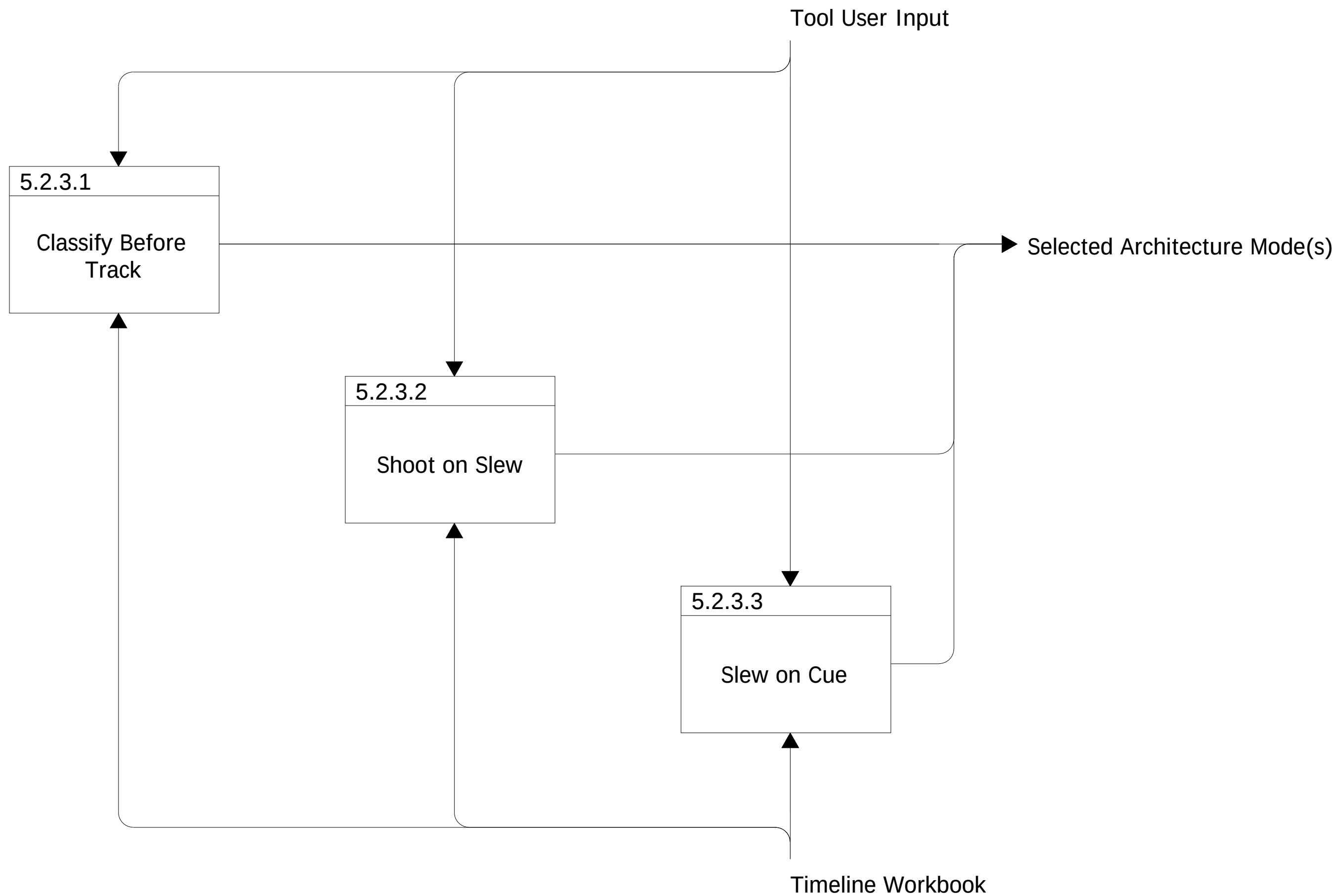
Setup Timeline Analysis FFBD



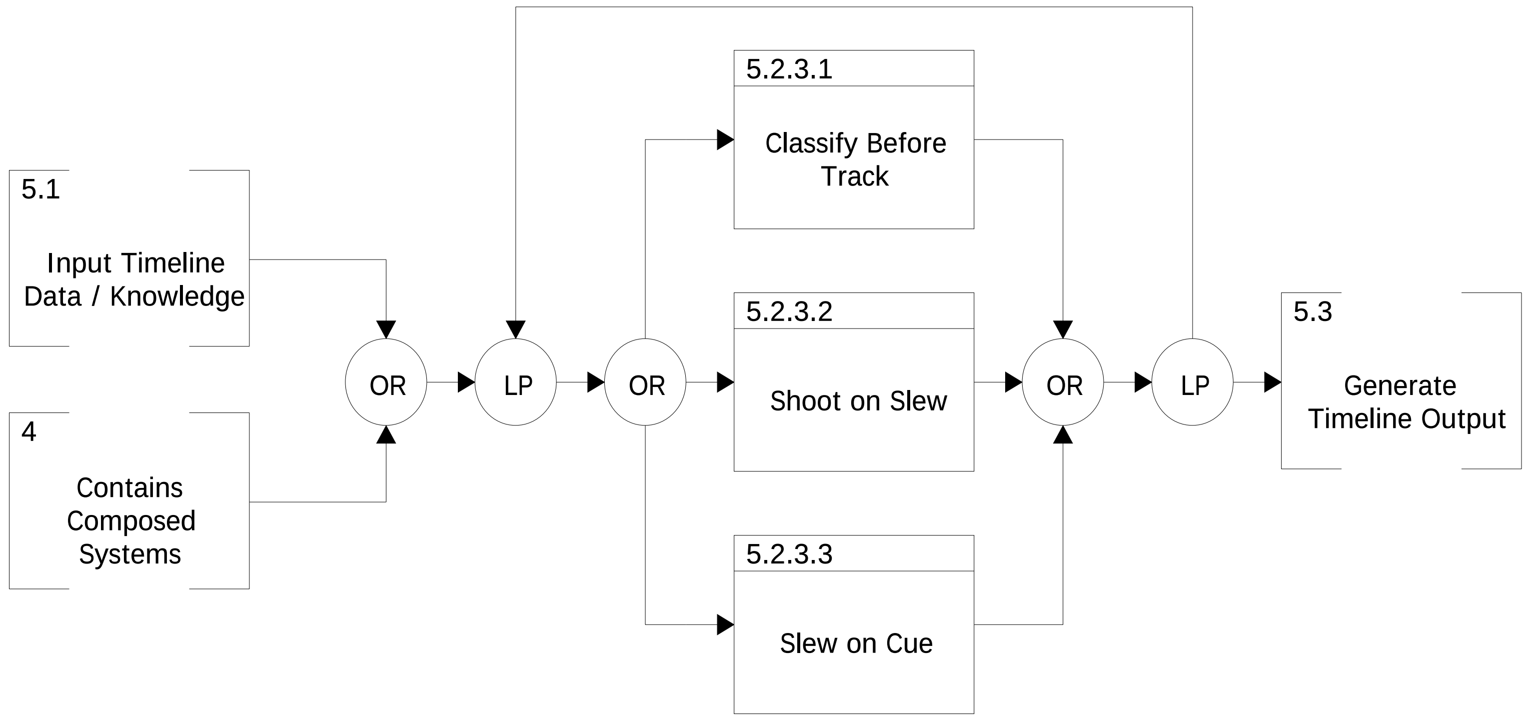
Setup Timeline Analysis EFFBD



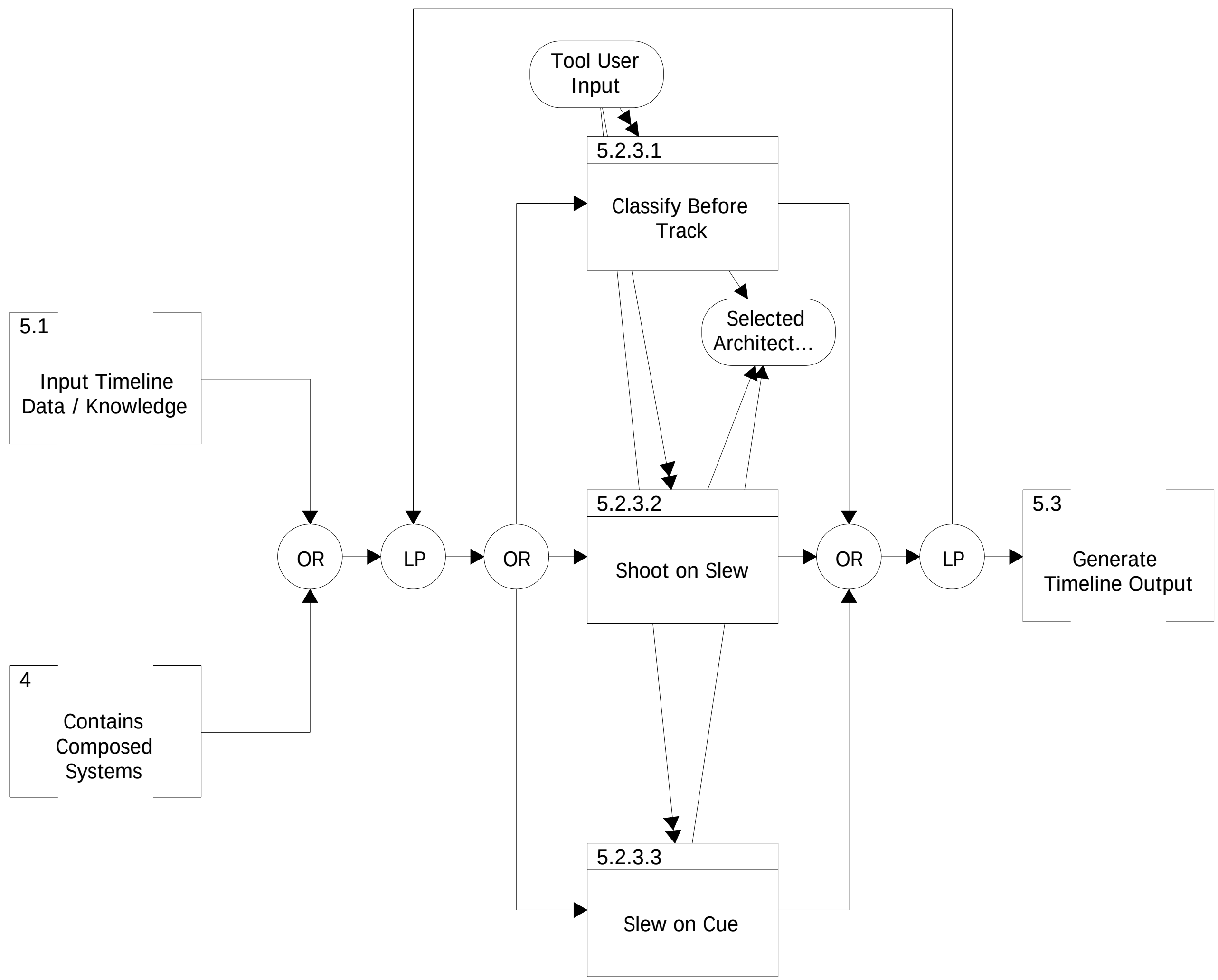
Select Architecture for Timeline Analysis IDEF0



Select Architecture for Timeline Analysis FFBD



Select Architecture for Timeline Analysis EFFBD



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The Systems Engineering Process was instrumental to the success of the APS Trade Study.

Supported by:
Joint Interoperability Test Command

Defense Information Systems Agency
Department of Defense

Case Study: Net-Centric Mission Thread Modeling and Analysis

Dr. Prem Jain pjain@Mitre.org
Brian Pridemore
Aumber Bhatti
MITRE Corporation

NDIA Systems Engineering Conference, San Diego
October 2007

Agenda

- Need to early verify net-centric information strategies
- Mission Level Model (MLM) experimentation for net centric C2

Net Centric Operations

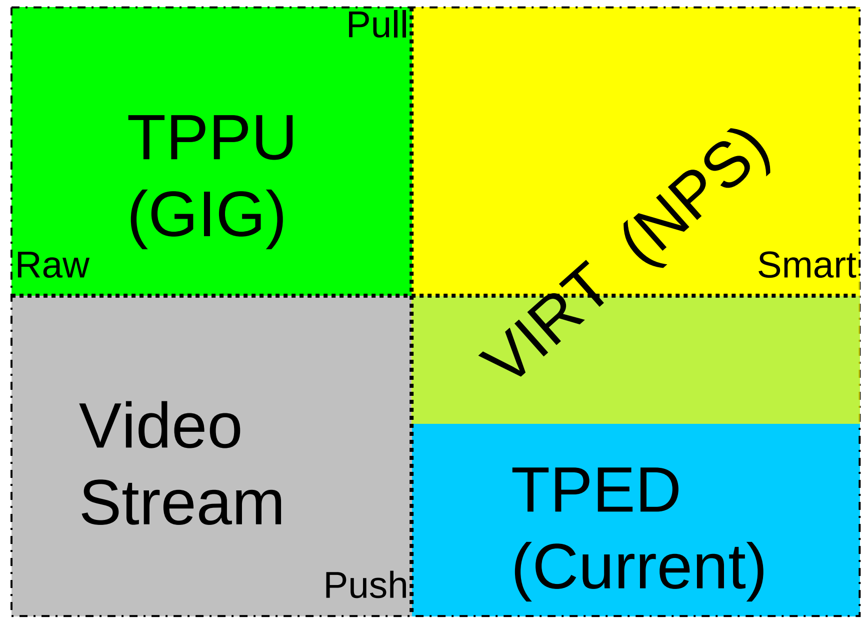
- An information superiority-enabled concept of operations that generates increased combat power by networking:
  - Sensors
  - Decision makers
  - Shooters
- Achieve:
  - Shared awareness
  - Increased speed of command
  - Higher tempo of operations
  - Greater lethality
  - Increased survivability
  - A degree of self- synchronization

MITRE

Must define, refine and early verify information strategies that enable net centric operations

Operationally Effective
Net Centric Information Flows

- Net centric environment facilitates
  - Distributed computing
  - Distributed storage
  - Distributed Command & Control (C2)
- Net centric concepts must exploit inherent concurrency among
  - Operations
  - Systems
  - Operations and systems
- DoD is technically challenged to T&E complex temporal behavior emerging from
  - Data dependencies
  - Control dependencies
  - Resource sharing among activities
  - External asynchronous trigger's
- Leading to difficulties in testing NR KPP and its temporal variances (six sigma)



DoD needs a new M&S capability (MLM) to define, refine and early verify operationally effective net centric information flows.

TPPU: Task, Post, Process, Use
TPED: Task, Process, Exploit, Disseminate
VIRT: Valuable Information at the Right Time
NPS: Naval Post Graduate School

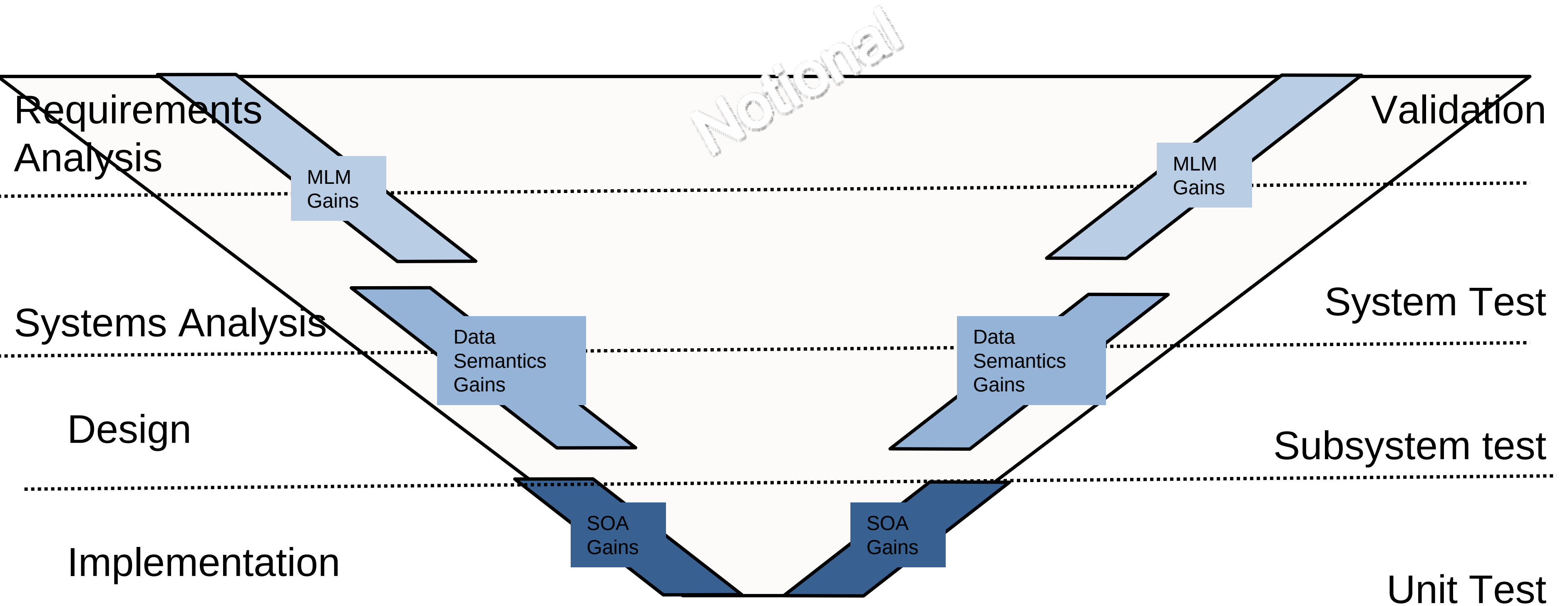
Need for Executable Mission Threads

- Mission threads have been the foundation of DoD acquisition
  - Critical Operational Issues are described via mission context
  - CDD includes DoDAF OV6C to describe mission threads
  - JFCOM is further refining NECC CDD via Capability Definition Package capturing operational threads
  - NECC program is developing Engineering Mission Threads (EMT) for requirements analysis
  - Operational T&E community describes its test via mission threads
- Executable mission thread modeling is a MUST to develop net centric capabilities
  - Hard to describe concurrency (implicit in net centric capabilities) in the current textual documentation practice impractical.
  - Necessary to have a standard to capture executable mission threads to compose mission threads developed by multiple stakeholders and to eliminate duplication and confusion
- Mission thread modeling must provide a collaborative environment to develop operational concepts throughout the acquisition cycle: Define, Refine and Verify capabilities

MITRE

Current requirement documentation methods are **inadequate** for DOD net centric acquisitions

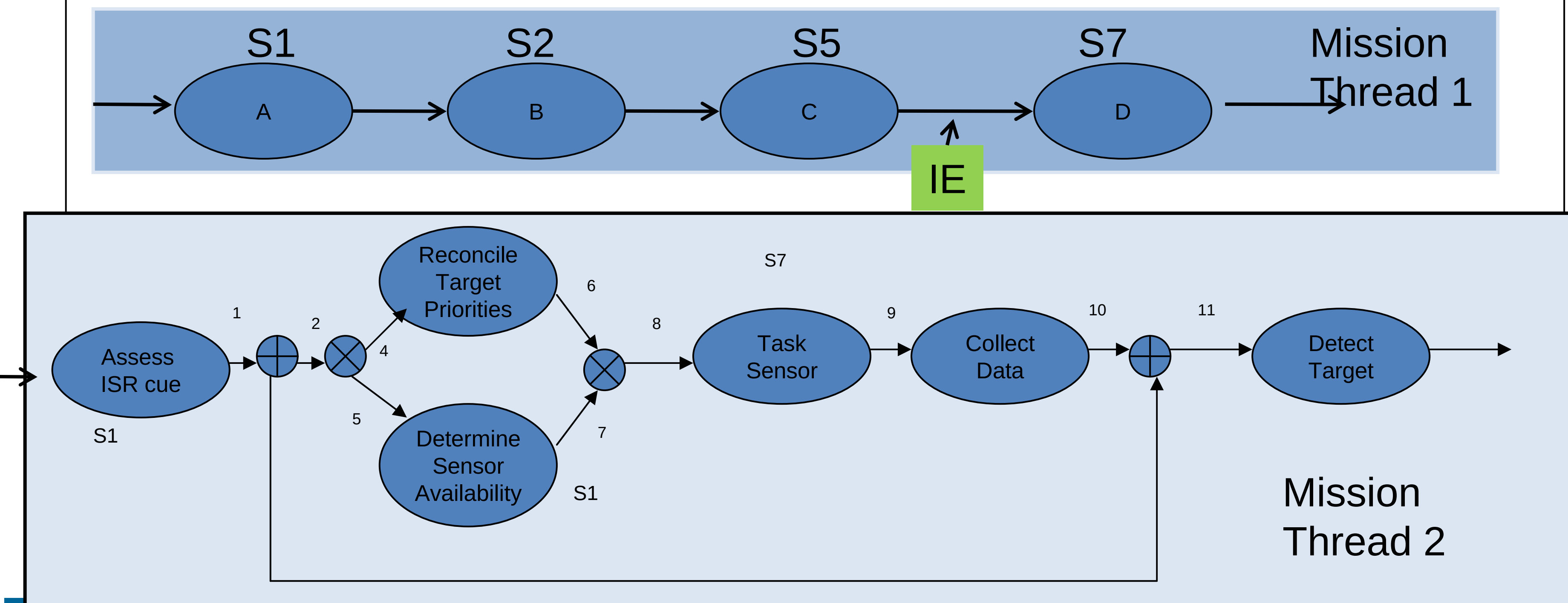
Narrow the Exponential Widening 'V'



Time from concept definition to deployment increases exponentially with complexity

MLM 101

- Information exchanges (IE) are **information events** among two entities (systems, operations)
- MLM captures end to end information flow among multiple entities supporting the mission
  - **Information flow is a sequence** of information events among mission end points
- Net centric operations require **concurrent information flows** (mission threads)
  - **Pipeline** allows multiple simultaneous executions of the same mission thread
  - **Parallelism** allows simultaneous execution of different mission threads, which could share resources



Selected MLM Technologies

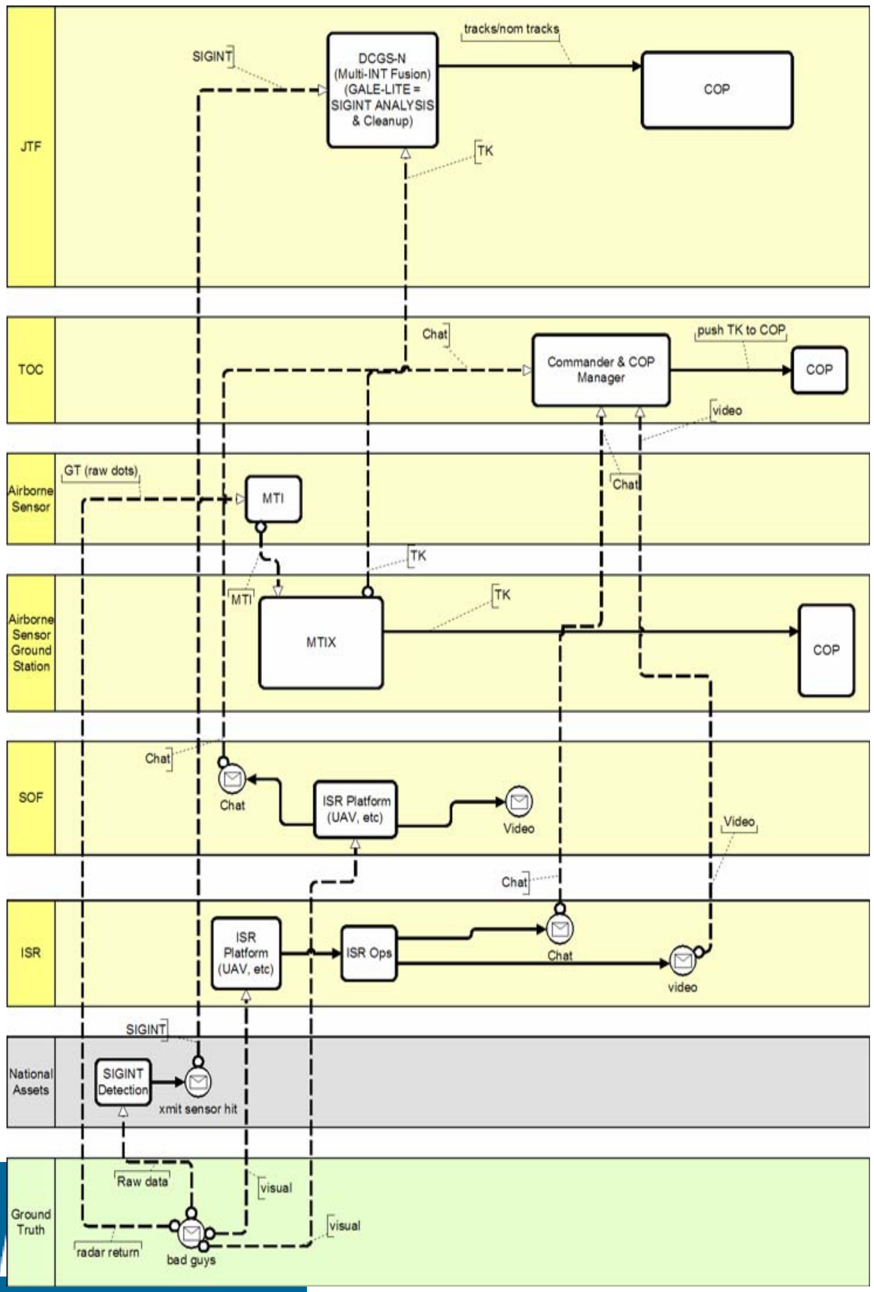
- Based on standards and COTS products
- Business Process Modeling Notation (BPMN) OMG standard for mission thread modeling
- iGrafx COTS tool for mission simulation and visualization
- Minitab COTS tool for design of experiments and analysis
- Business Process Executable Language (BPEL) for capturing SOA test workflow
- Automated generation of BPEL from BPMN
- ActiveBPEL COTS simulation engine for SOA test
- SOA standards: SOAP, XML . . .

Benefits

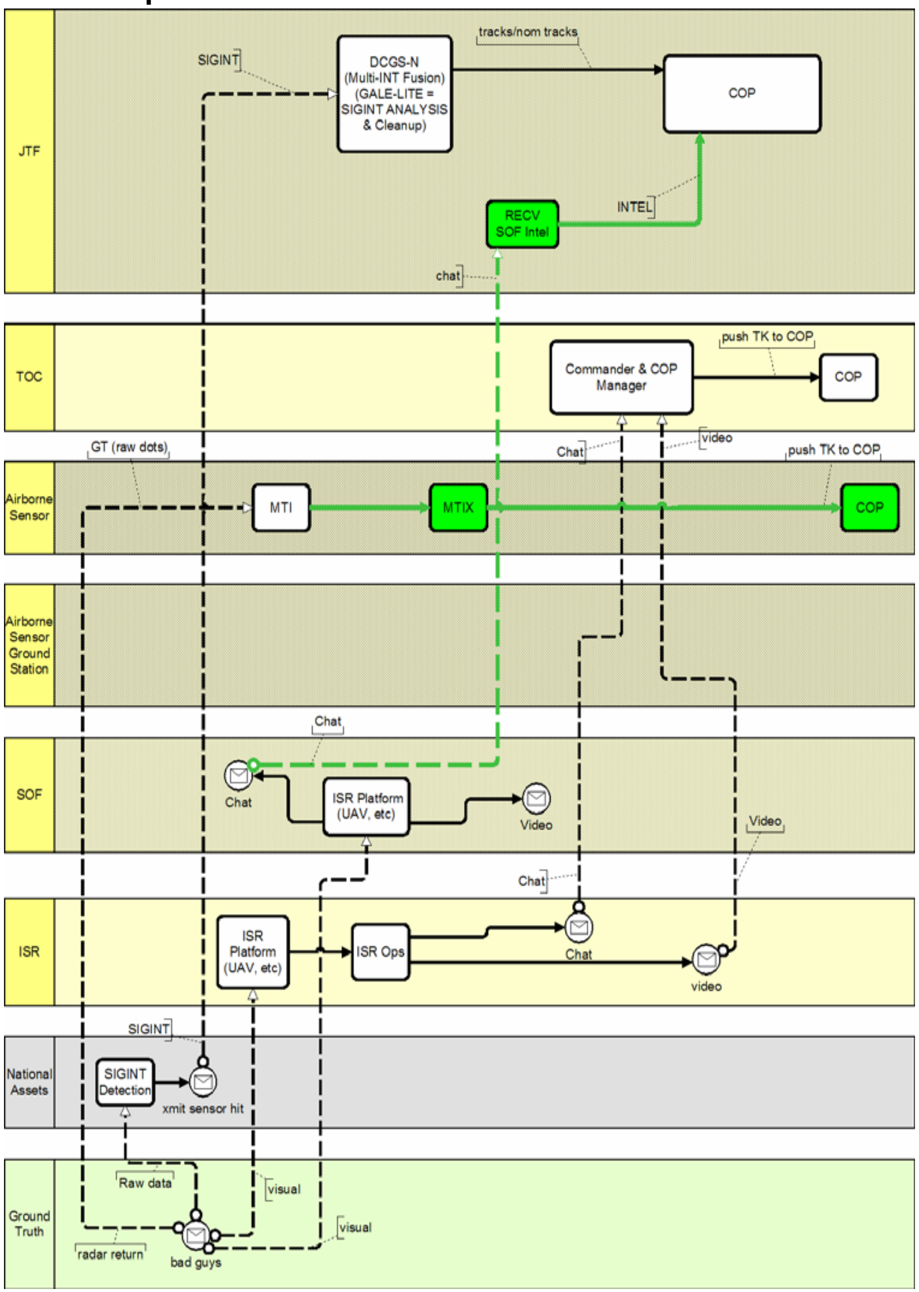
- Improves development &test efficiency via process automation
- Reduces cost by implementing automation via converging standards
- Eases technology transitions to multiple stakeholders via COTS

MLM Experimentation for C2

Basecase: Experiment #96



Airborne Sensor Case: Experiment #106



Moving C2 task to Airborne Sensor (AS)

Basecase #96

Flows	Process @	Communication Type
ISR -> TOC	TOC	Video/Chat
AS->GS	GS	MTI/TK
GS->JTF	GS and JTF	MTI, Update COP
SOF->TOC	SOF	Chat

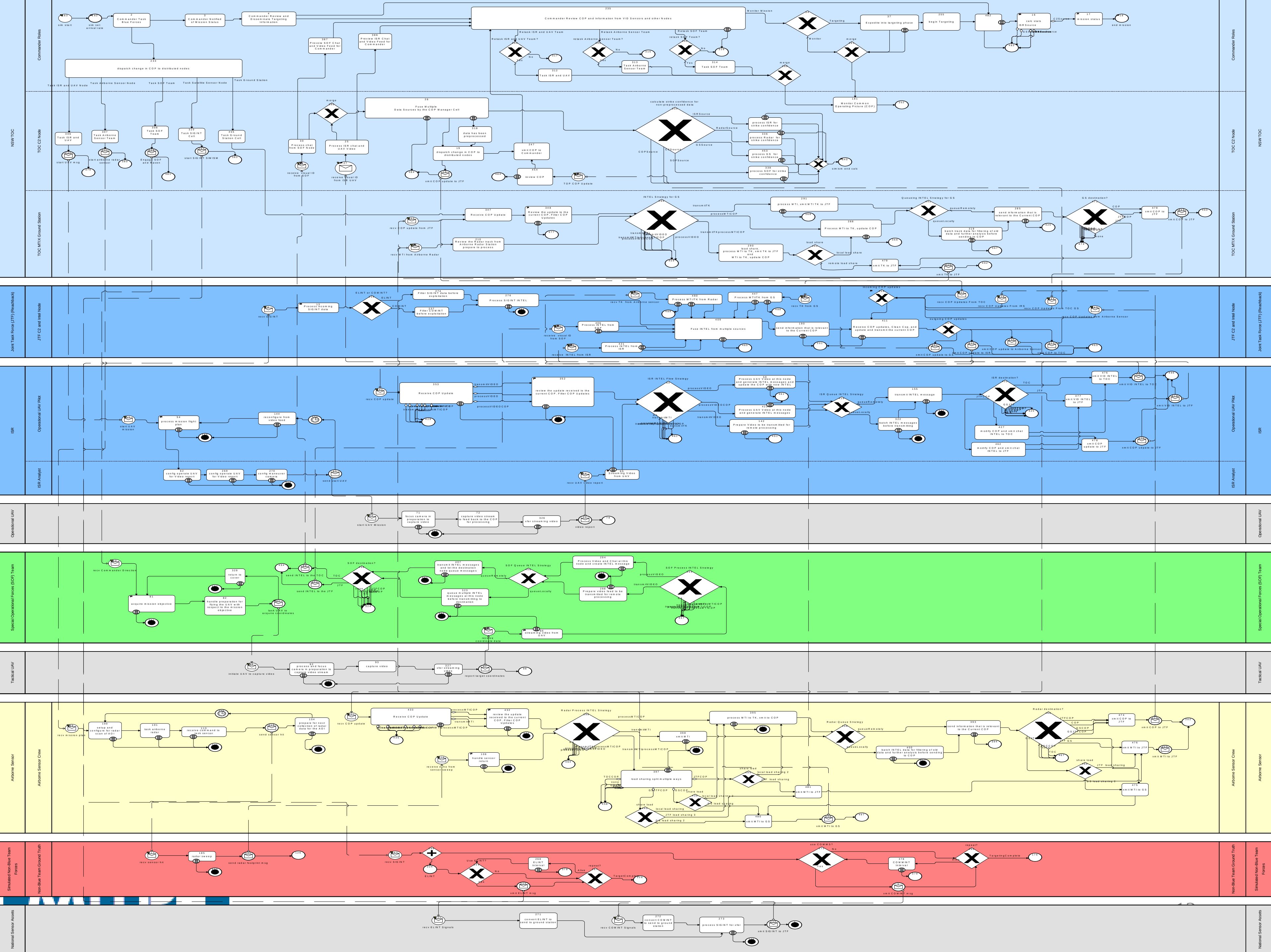
Airborne Sensor Experiment #106

Case #106

Flows	Process @	Communication Type
ISR -> TOC	TOC	Video/Chat
AS->	AS	Update COP
----------	---------	----------------
SOF->TOC	SOF	Chat

AS: Airborne Sensor
GS: Ground Station
SOF: Special Operation Forces (SEAL Team)
TOC: Tactical Operations Center
JTF: Headquarters/Rear

MITRE



NSW TOC
Commander Roles
TOC C2 Node
TOC MTIX Ground Station
Joint Task Force (JTF) (Reachback)
JTF C2 and Intel Node
ISR
Operational UAV Pilot
ISR Analyst
Operational UAV
Special Operational Forces (SOF) Team
Tactical UAV
Airborne Sensor
Airborne Sensor Crew
Simulated Non-Blue Team Forces
Non-Blue Team Ground Truth
National Sensor Assets
Commander Task Blue Forces
Commander Notified of Mission Status
Commander Review and Disseminate Targeting Information
Commander Review COP and Information from VID Sensors and other Nodes
Monitor Mission
Targeting
Expedite into targeting phase
Begin Targeting
mission status
end mission
dispatch change in COP to distributed nodes
Task ISR and UAV
Task Airborne Sensor Team
Task SOF Team
Task SIGINT Cell
Task Ground Station Cell
Fuse Multiple Data Sources by the COP Manager Cell
dispatch change in COP to distributed nodes
Monitor Common Operating Picture (COP)
calculate strike confidence for non-preprocessed data
process ISR for strike confidence
process Radar for strike confidence
process GS for strike confidence
process SOF for strike confidence
review COP
TOP COP Update
INTEL Strategy for GS
process MTI, smit MTI TX to JTF
Process MTI to TX, update COP
Queueing INTEL Strategy for GS
send information that is relevant to the Current COP
GS destination?
Receive COP Update
Process SIGINT INTEL
Fuse INTEL from multiple sources
Process MTI/TX from Radar
Process MTI/TX from GS
Receive COP updates, Clean Cop, and update and transmit the current COP
Receive COP Update
ISR INTEL Flow Strategy
ISR Queue INTEL Strategy
transmit INTEL message
ISR destination?
process mission flight plan
reconfigure from video feed
config operate UAV for video report
config operate UAV for video report
config maneuver camera
streaming video from UAV
focus camera in preparation to capture video
capture video stream to feed back to the COP for processing
sfer streaming video
video report
acquire mission objective
handle preparation for flying the UAV with respect to the mission objective
SOF destination?
SOF Queue INTEL Strategy
SOF Process INTEL Strategy
streaming video from UAV
process and focus camera in preparation to capture video stream
capture video
Receive COP Update
Radar Process INTEL Strategy
Radar Queue Strategy
Radar destination?
load sharing split multiple ways
radar sweep
send radar footprint msg
convert ELINT to send to ground station
convert COMINT to send to ground station
Process SIGINT for sbs

Experimentation Setup

- 5 workloads
  - 1 to 5 targets
- 360 information Flow Strategies

  =[6 ISR flows] * [4 SOF flows] * [15 AS/GS flows]

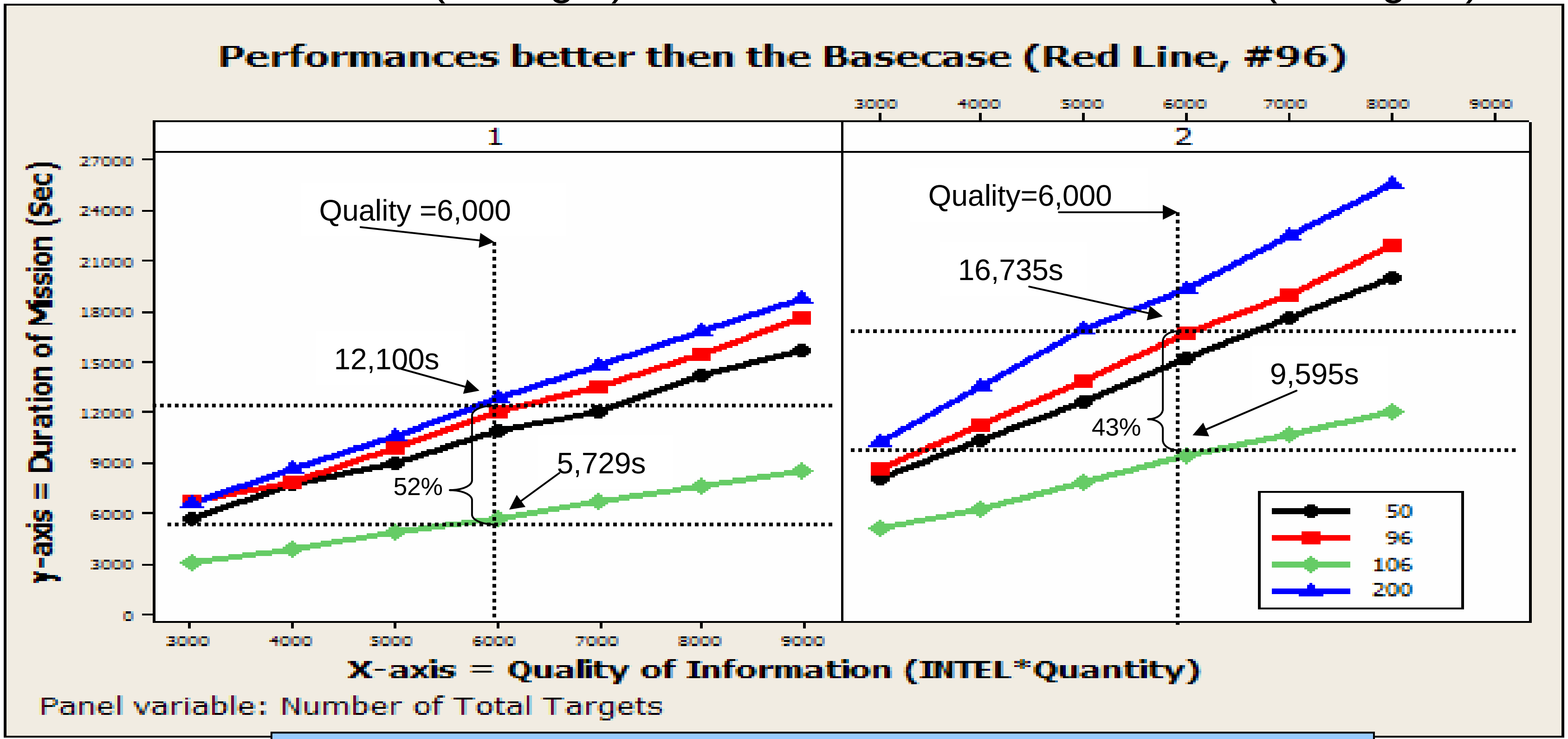
Sensor	Contribution / Hit	Typical Hits for F2T2	Information Quality
AS/GS	1	1,250	1,250
ISR	25	40	1,000
SIGINT	22	45	990
SOF	65	17	1,105
Fusion			1,655
Total			6,000

AS: Airborne Sensor
GS: Ground Station
SOF: Special Operation Forces (SEAL Team)
SIGINT: Signals Intelligence

Improved TST Time for the Same Information Quality

52% Improvement in TST for processing at Airborne Sensor (AS) case for the <u>same Quality</u> of Information of 6,000 (1 Target)

43% Improvement in TST for processing at Airborne Sensor (AS) case for the <u>same Quality</u> of Information of 6,000 (2 Targets)

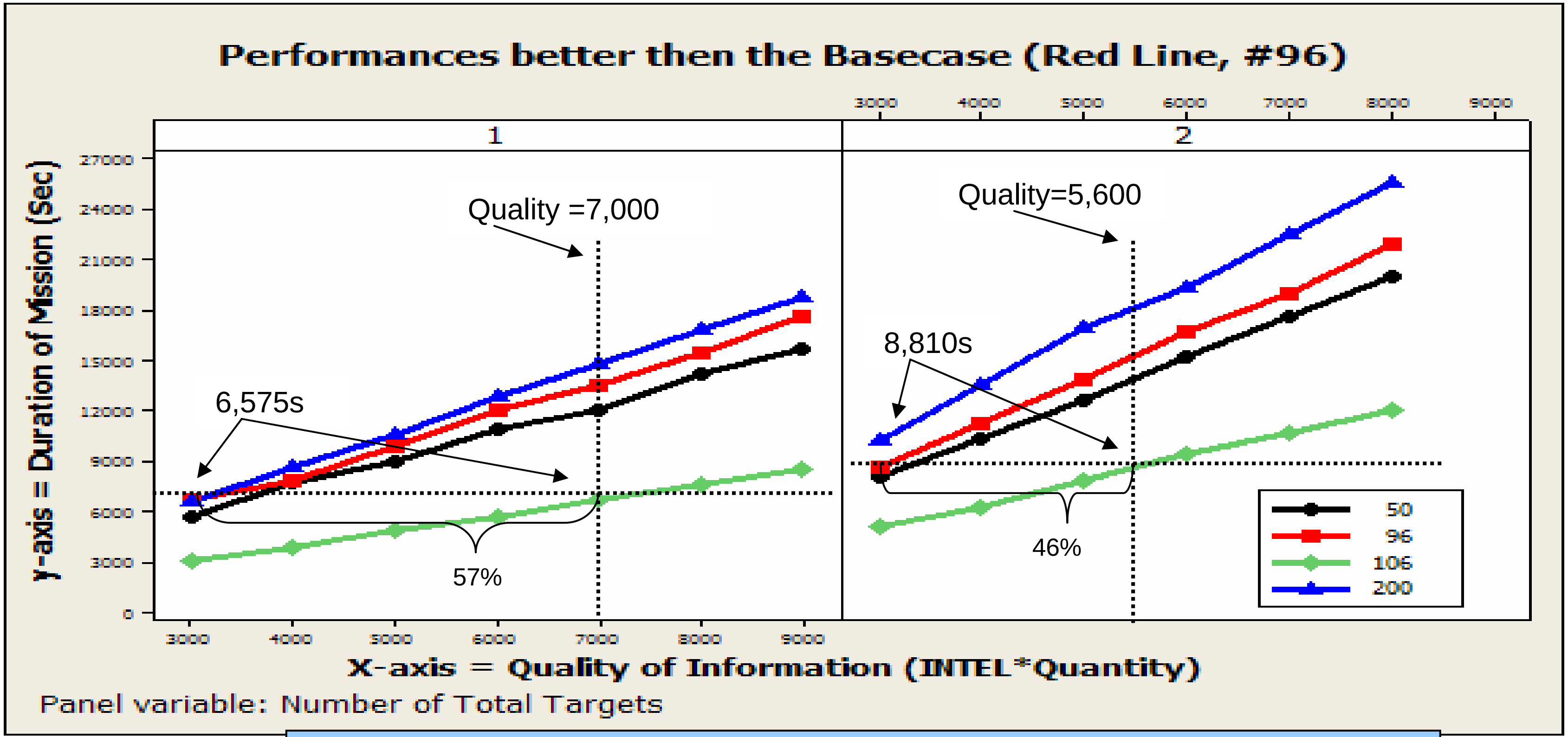


Moving processing to AS has potential to reduce TST time by 41% to 52% for the same information quality

Improved Information Quality for the Same TST Time

57% Improvement in Quality of Information for processing at Airborne Sensor (AS) case for the same F2T2 time of 6,575 sec (1 Target)

46% Improvement in Quality of Information for processing at Airborne Sensor (AS) case for the same F2T2 time of 8,810 sec (2 Targets)



Moving processing to AS has potential to increase information quality by 46%-57% for same TST time

Operational Capacity for an Information Strategy and TST Time

	TST time = 2-hours	TST time = 4-hours
AS 1-target	YES	NO
AS 2-targets	NO	YES
AS 3-Targets	NO	MAYBE meet TST
Base case 1-target	NO	YES
Base case 2-targets	NO	NO

- 2 Hour TST: Need AS- Information Strategy even for one target
- 4 Hour TST: AS-Strategy can do 2-targets and base case can only do 1-target

MITRE

AS: Airborne Sensor Strategy #106
Basecase: Experiment #96
TST = Time Sensitive Targeting

Conclusions

- Acquisition of Net centric operational capability needs a new M&S capability to support analysis of required capabilities
  - Define, refine and early verify mission performances
  - Complementary to net centric operational exercises
- COTS solutions are matured enough to quantitatively assess mission performances via simulation
  - BPMN standard based
- Further research is needed to
  - Improve modeling of the sensor contribution to commander confidence
  - Add stochastic simulation

MITRE

Questions?

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System Test and Evaluation (T&E) in the DARPA Immune Building Program

Mark Saxon

Research Scientist

CB Attacks, Accidents, and Threats

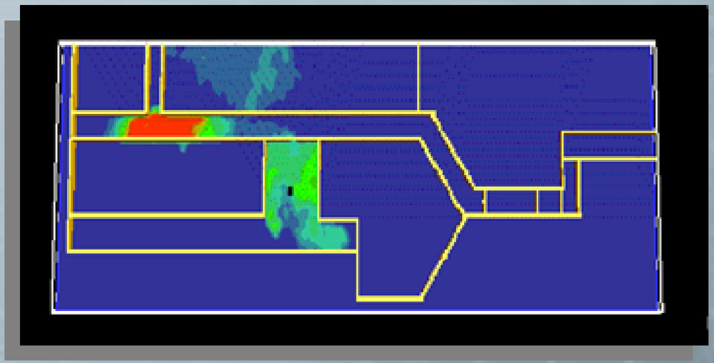
- Threats
  - CWAs and TICS
  - BWAs
  - Radiological Agents

- CB Attacks and Accidents
  - 1984 TIC Methyl isocyanate, Bhopal, India
    - 3,800 deaths, thousands disabled
  - 1995 Nerve gas (Sarin), Tokyo, Japan (subway)
    - 12 deaths, 1000+ illnesses
  - 2001 BWA Anthrax (Florida and New York)
    - 5 deaths, 10,000 treated

CB Building Protection Overview

Why are buildings vulnerable to CB attack?

- Containment of CB agents within a confined space allows concentrations to rapidly reach and sustain lethal levels
- CB agents are effectively transported throughout a building by mechanical systems
- Population densities are high in buildings
- Agents can be delivered covertly
- Numerous adsorbing surfaces that make building restoration difficult



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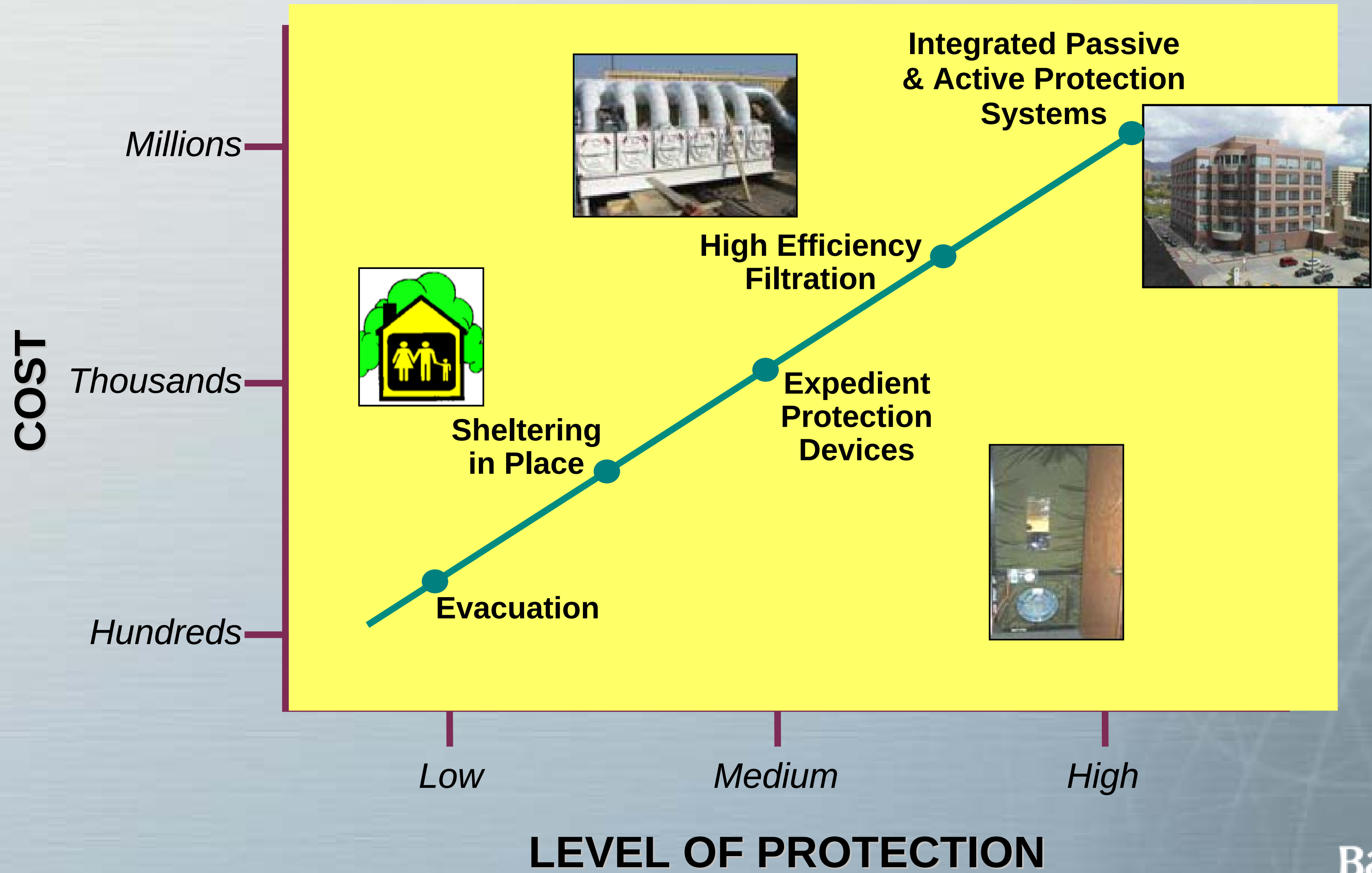
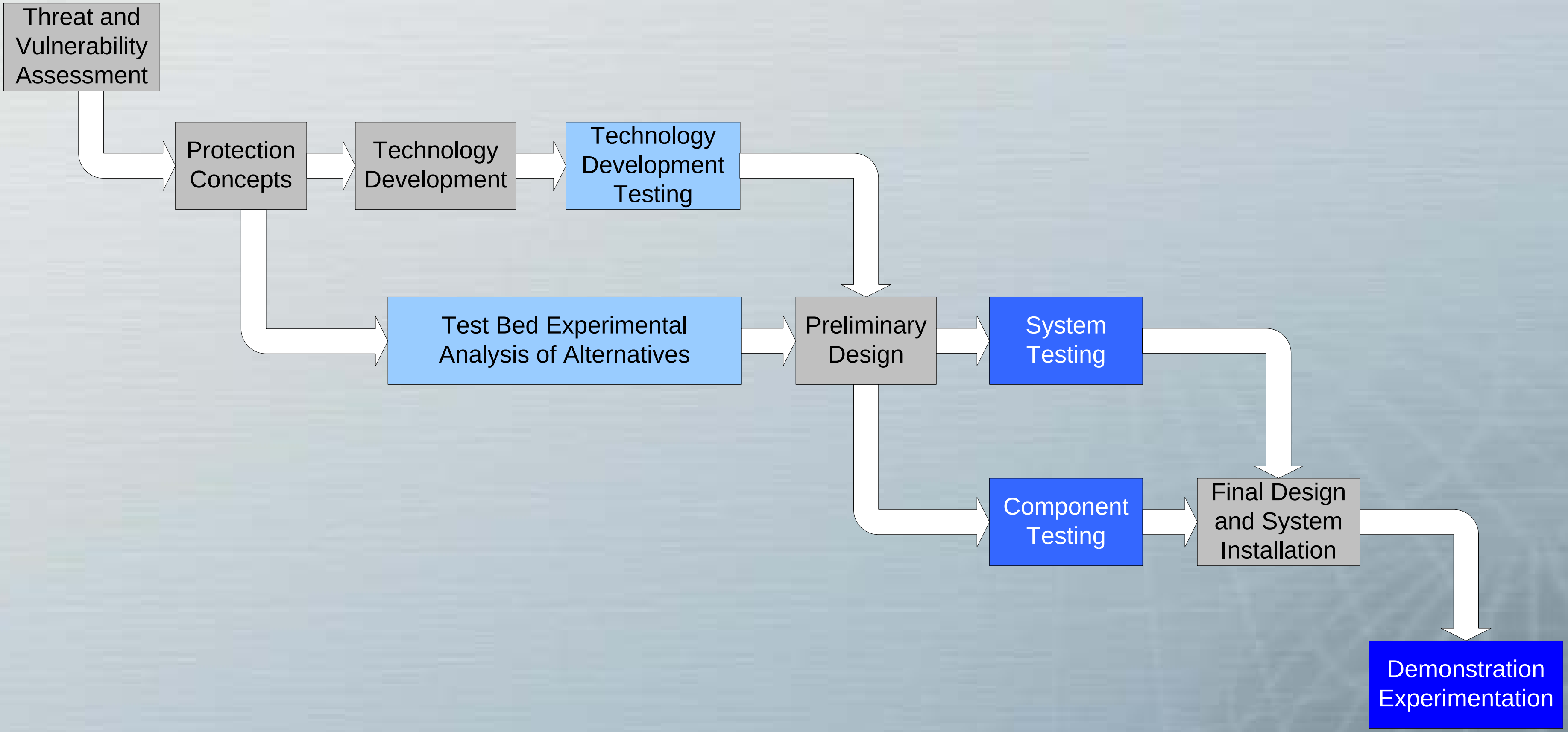
Range of Protection Solutions



DARPA Immune Building Overview

- Objective: To make military buildings less attractive targets for attack with CB weapons
  - Protect human occupants
  - Restore the building to function quickly after an attack
  - Preserve forensic evidence for medical treatment and retaliation
- Protect all parts of the building against internal and external releases of a wide range of agents
- IB Program Accomplishments
  - Developed a highly effective building protection system
  - Extensively tested protection system and subsystems in a full-scale test bed
  - Installed and demonstrated system design in an operational building

System Process Flow



Threat and Vulnerability Assessment

- Threat and Vulnerability Assessments (TVAs) are performed to identify requirements for building protection systems
  - Threat Scenarios were client defined:
    - Agent Types
    - Release Masses & Locations
    - Exposure Limits
    - Environmental Conditions
  - Functional subsystems were developed to counter these threats
    - Filtration/Neutralization
    - Segmentation
    - Detection and Forensics
    - HVAC Responses

Protection Concepts

- TVA Outputs:
  - Testable requirements
  - Technology development needs
  - Foundation for initial system protection concepts
- Initial protection concepts were developed based on the requirements of the TVA.
  - Extensive modeling analysis performed to down-select the most promising strategies
  - Generated an initial Test Bed design
  - Defined interfaces for technology development insertions into the system

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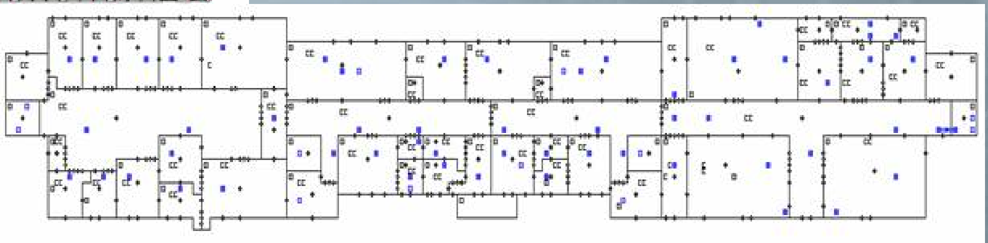
Technology Development Testing

- Key areas underwent small scale testing/optimization prior to integration
  - Distributed CB Sampling System
  - Wall Leakage Specifications
  - Passive and Active Agent Removal
  - Chemical Forensics Sampler
  - Vestibule Testing
- Generated construction requirements
- Technologies tested in a full scale building and further optimized

Immune Buildings Test Bed Facility

- Test Bed constructed in former barracks building at Fort McClellan in Anniston, AL
  - Three stories with a quarter basement, ~ 30,000 ft^2
  - Entire building used in Integrated Systems Experimentation phase; top two floors only in Demonstration phase
  - Multiple HVAC zones with various protection strategies possible
  - Performed over 250 full scale building experiments

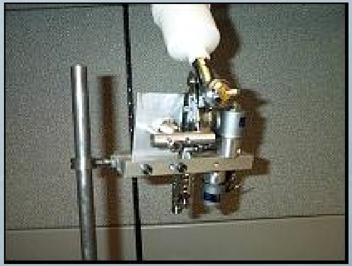


CONTAM Model Schematic

Test Bed Experimentation

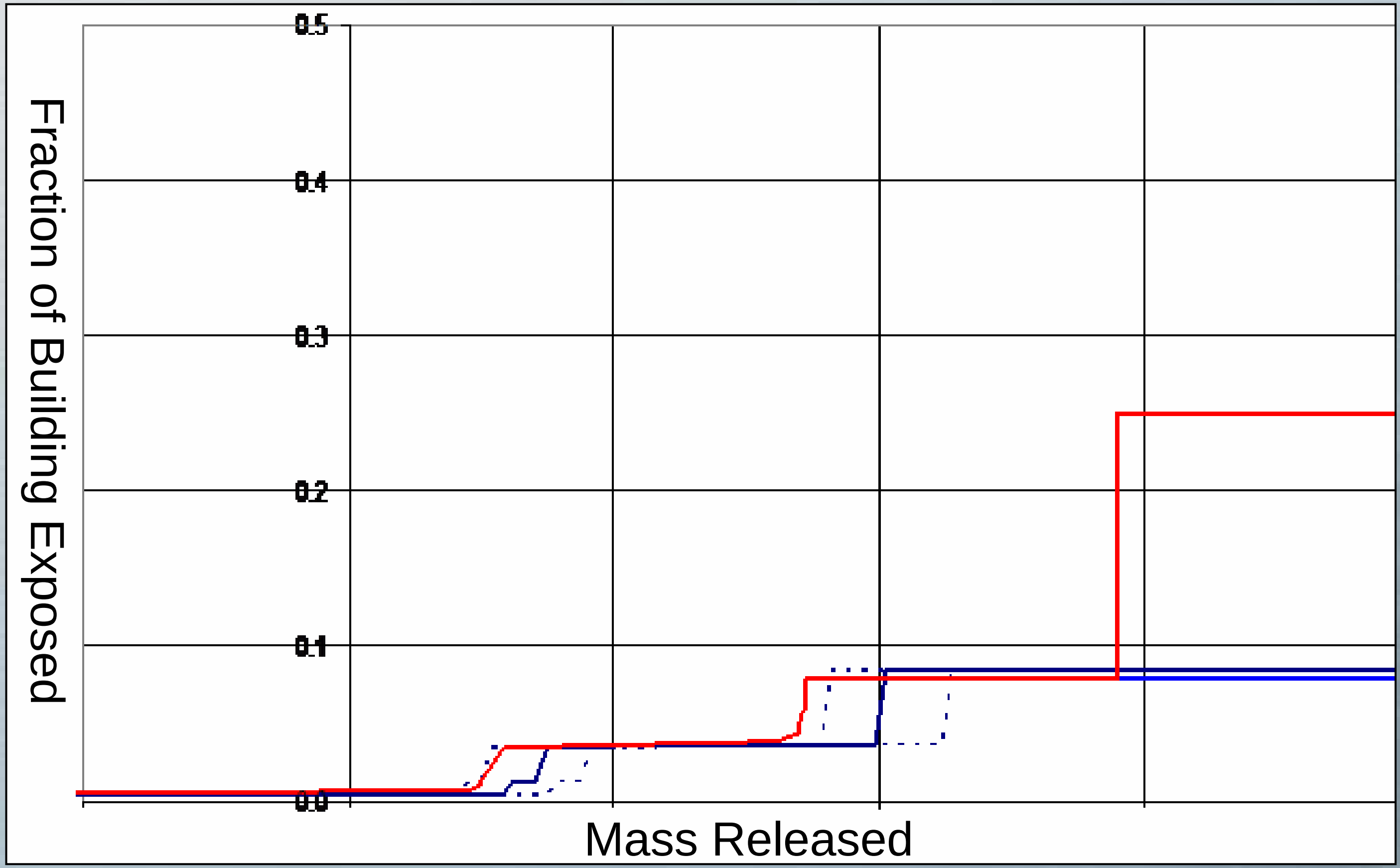
- Testing
  - 4 Simulants to represent CB threats
  - Methods to create repeatable releases of simulants were developed
  - Automated sampling network
    - Whole building coverage
    - 3 types of collectors
    - Remote control of simulant release and sample collection
- Analysis
  - On-site laboratory for chemical analysis
  - Optical analysis of particulate simulants
  - Simulant to agent correlations
  - Data analysis methods (including uncertainty analysis)






Program Metrics

- Metrics
  - Fraction of Building Exposed (FBE)
  - Fraction of Occupants Exposed (FOE)
  - Life-cycle Cost



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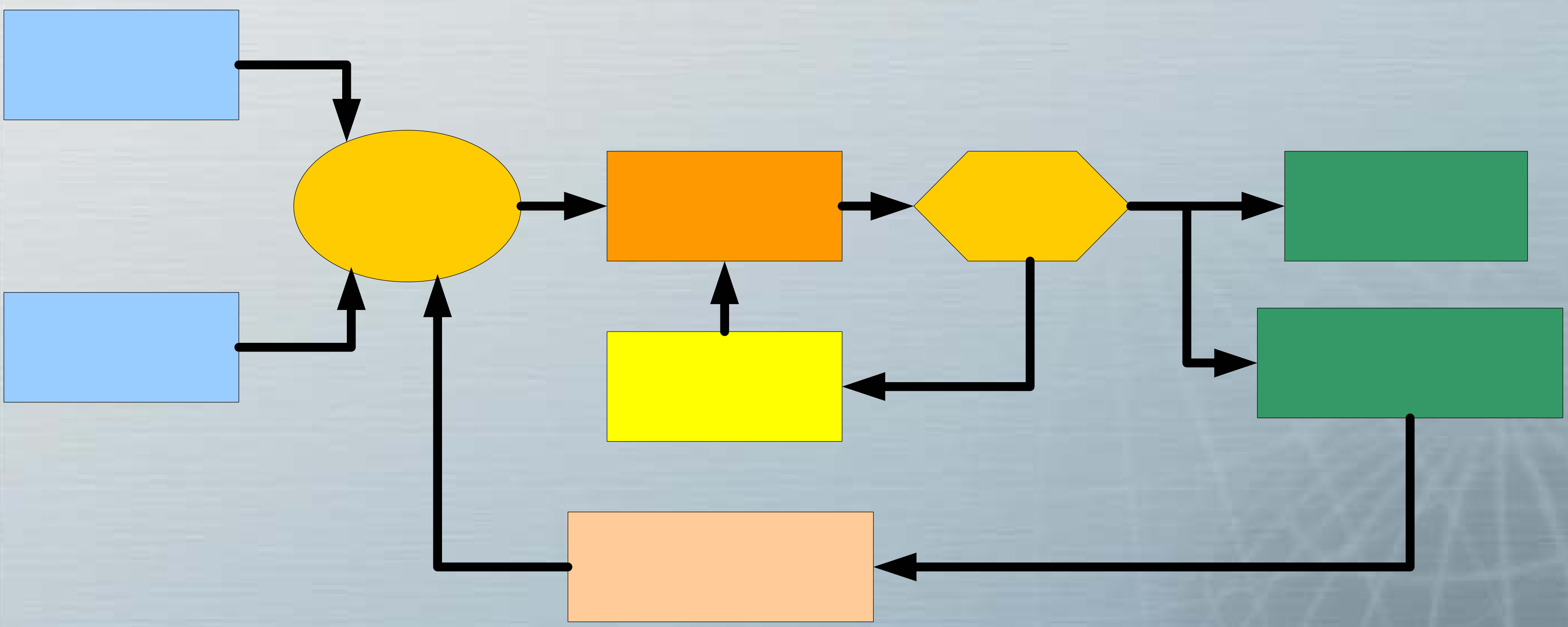
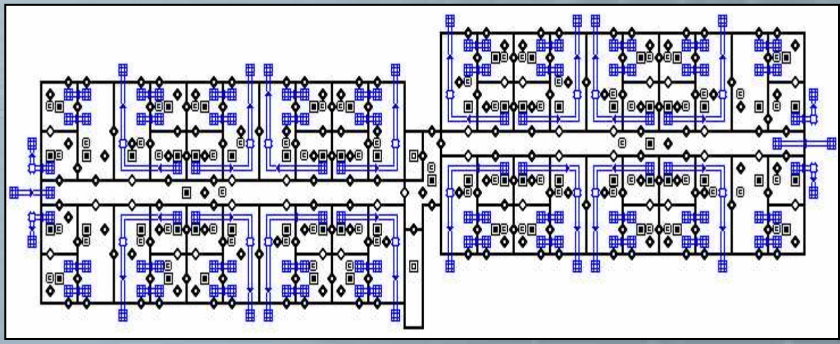
Modeling / Experimentation Process



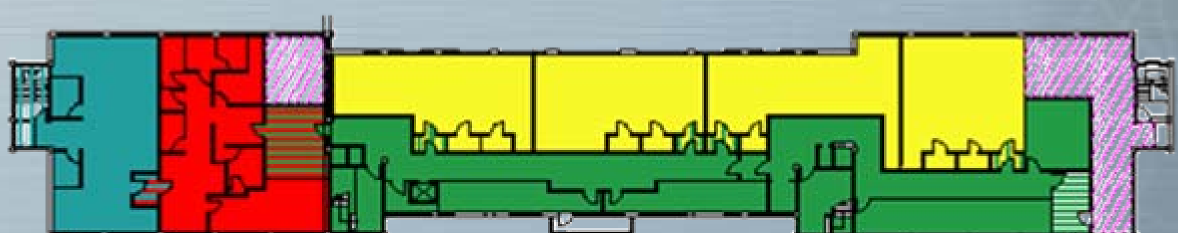
Modeling and Simulation

- Every test performed during the Immune Building Program was modeled prior to experimentation
- CONTAM modeling, predicted the flow of contaminant throughout the building
  - Used to determine the optimum sampling locations
  - Generated data for alternate agents and mass releases
  - Generated data for locations where releases were not possible
- Test data were used to verify and improve model performance



Design Modification and Phase II Test Bed Testing

- The Phase I testing results guided the modifications from the protection concept to the preliminary design
- The Test Bed was reconstructed to represent the Demonstration building (preliminary design)
- Over 100 Tests were performed, results were gathered on the:
  - Overall system protection
  - Subsystem performance
  - Effects of human transport on the protection system



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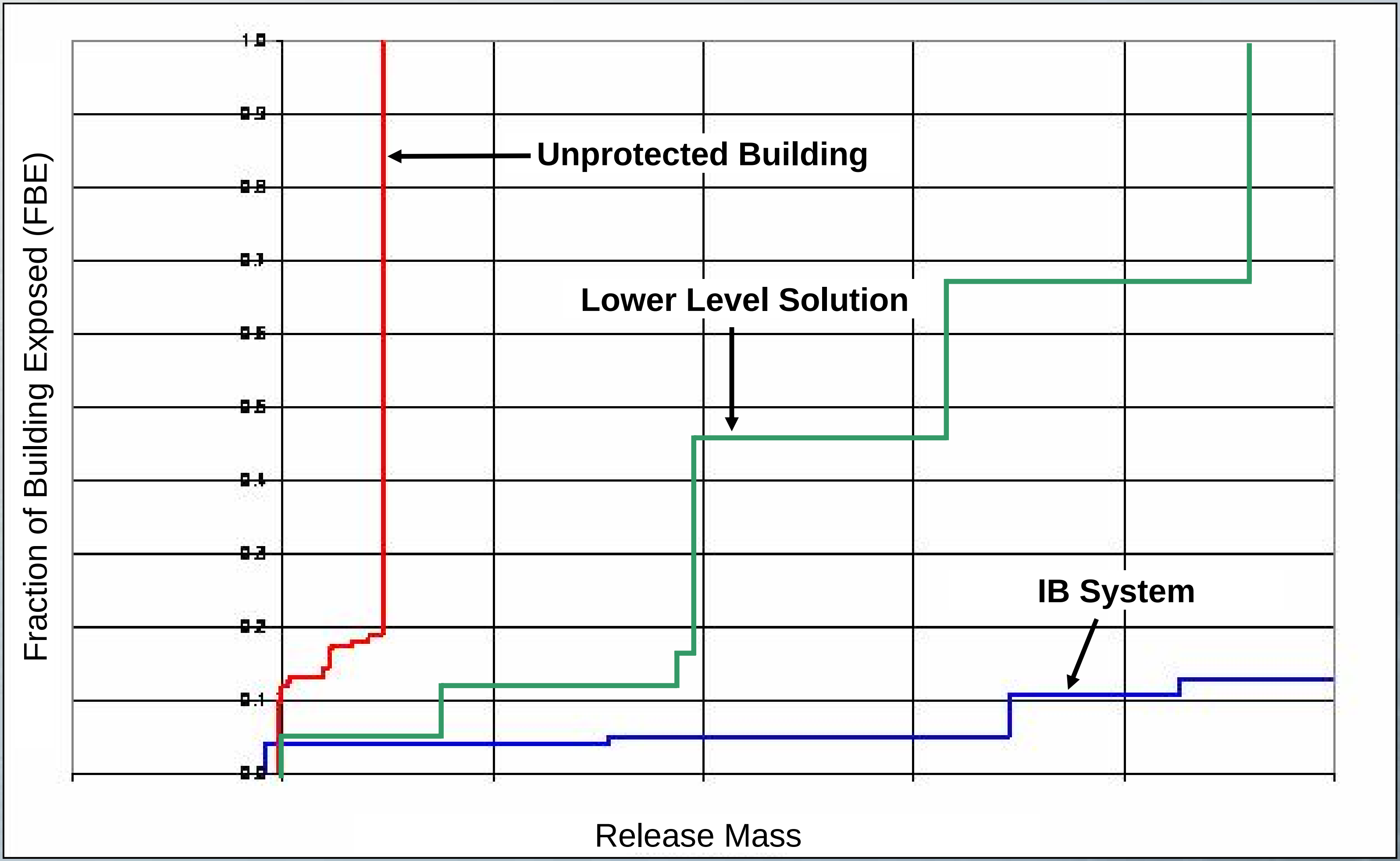
Design Optimization

- The final design was generated based on the results of the Preliminary Design testing
  - The Test Bed was modified during testing to reflect design changes as they occurred
  - The Final Design components were tested in the Test Bed
- The final design was installed in the Demonstration building
  - Applications of Lessons Learned from the Test Bed allowed for an expedient commissioning and characterization process
  - Performance Testing showed little deviation from the Final Test Bed design

IB Protection Performance



Conclusions / Results

- The Immune Building program employed a T&E centric approach to developing designs per good Systems Engineering practice
- Data gathered in early stages of the design process allowed optimization prior to installation avoiding costly post-construction modifications.
- Integrating T&E into all stages of the design process created a system that was verified through testing to meet client requirements.
- End result is a state of the art system that provides the highest level of protection against CBR threats.

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Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula

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24 October 2007

Overview

- Background
- Project Overview
- Work to Date
- Way Forward

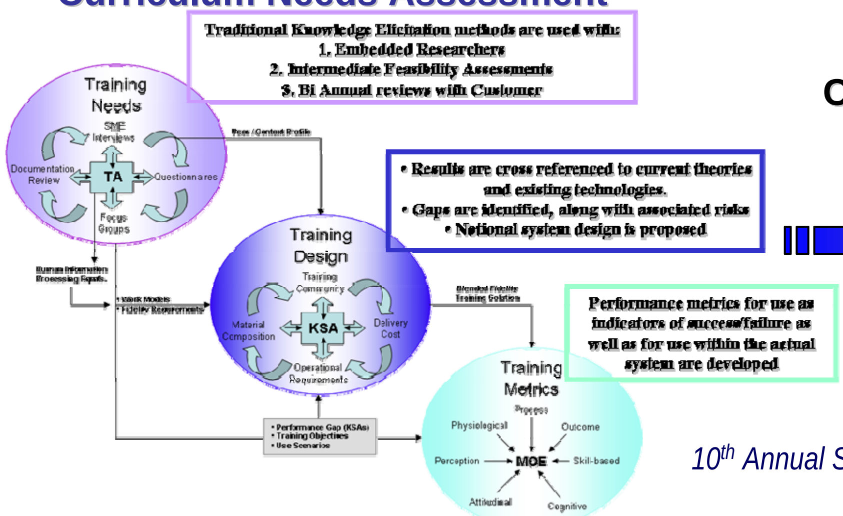
Background

- M&S Acquisition/T&E Mission - Enable the Department of the Navy to effectively use M&S within and across the Acquisition Enterprise
  - Need a unified approach for enabling the workforce to determine WHICH tools to use, WHEN to use them, and HOW to use them across development lifecycle
  - Need education and options to improve workforce capabilities to select and use M&S tools effectively and efficiently. These include
    - Initial education and training, refresher training, continuing education, and certification opportunities once in a career path
- Ultimate Goal: M&S savvy DoD acquisition workforce
  - Able to apply M&S tools appropriately to enhance warfighting capability, reducing lifecycle development time and costs.

Spiral One: Requirements

- Emphasis:
  - Developing and refining the needs assessment and performance metrics
    - Identify partner requirements (Joint Curriculum Definition)
  - Content requirements
  - Individual KSA assessment and knowledge mapping tool
  - Instructional Vehicle Delivery specifications
  - Guidelines linking training content to knowledge gaps
- Methods will include:
  - State of the art assessment- Cross Service
  - Task Analysis: Content requirements/System capabilities
- Deliverable: Learning Matrix
  - Integrates: Individual educational background, learning style, and workforce role, and desired education end state

Curriculum Needs Assessment



Specify Instructional Vehicle

Classroom

Distance Learning

Tools

Learning Matrix

- Education gap analysis
- Knowledge Mapping
- M&S curriculum requirements
- Instructional Delivery System specs

Stakeholder Group

- Consists of members from throughout DoD
  - DASN RDT&E
  - AFAMS
  - HQDA
  - CVN
  - SPAWAR
  - COMOPTEVFOR
  - Future Combat System
- Embodies broad educational discipline representation

Market Segmentation

Educating the Acquisition and T&E Workforce in the More Effective Use of M&S:

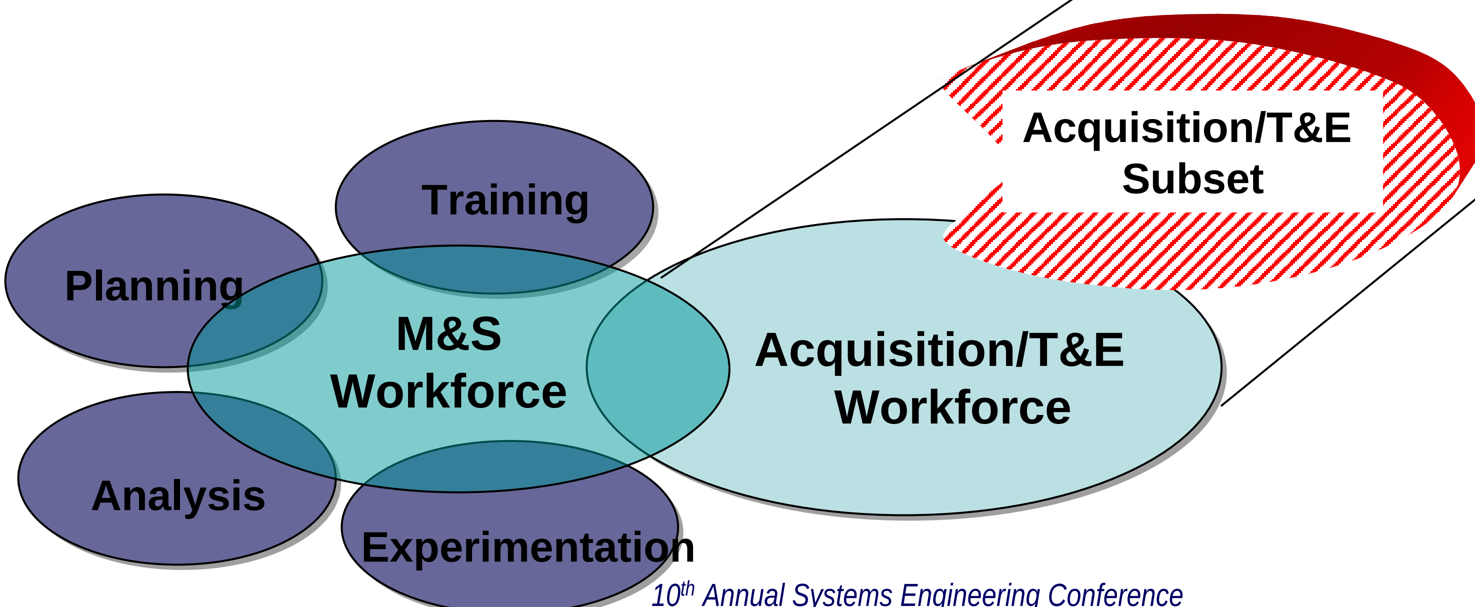
Market Schema

Training Levels

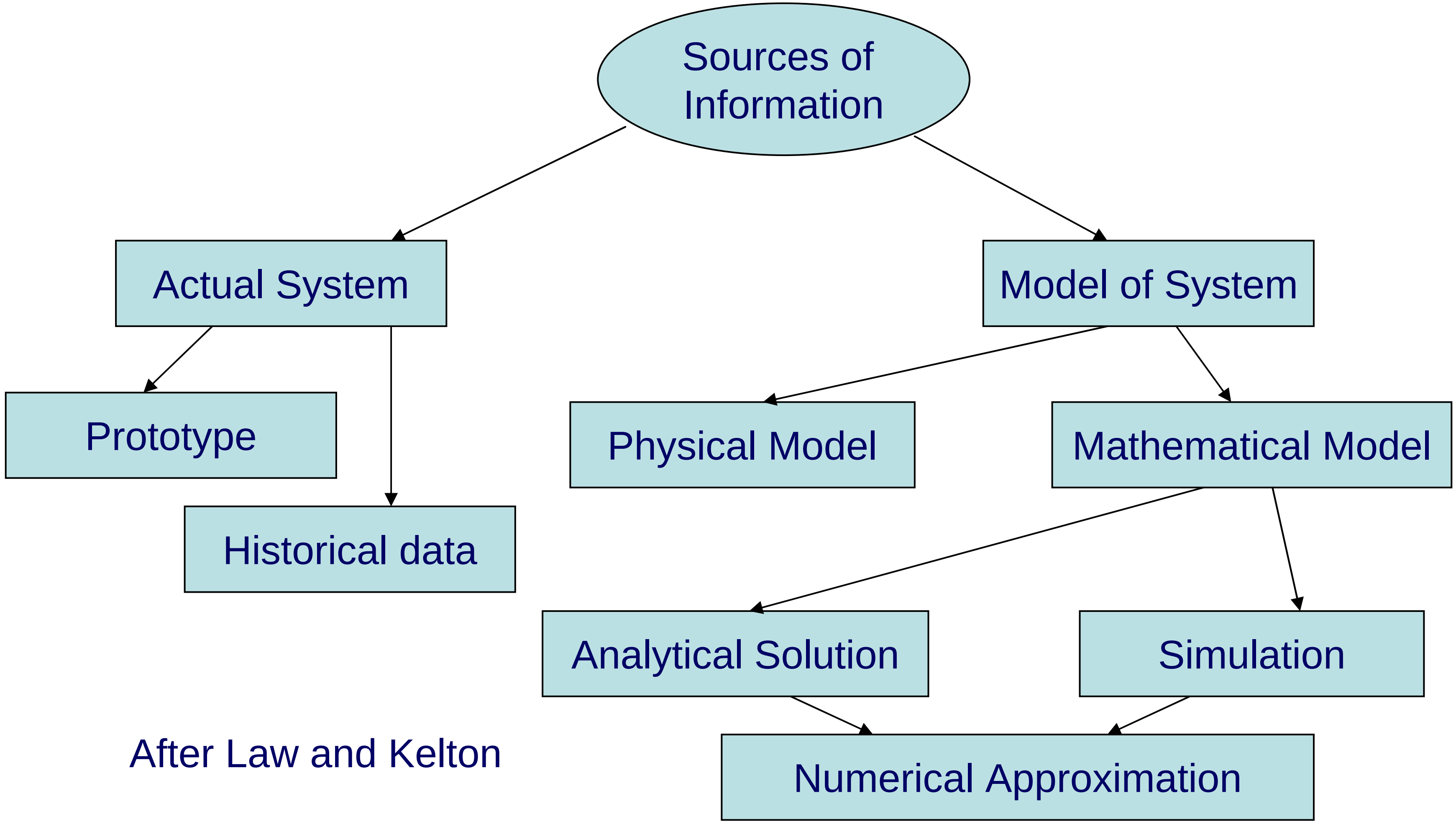
Executive
Management
Application
General Awareness

Acquisition Career Fields

Program Management
Systems Engineering
Test and Evaluation
Contracting
Logistics
Facilities Engineering
Auditing
Science & Technology
Information Technology
Business, cost estimating, and financial mgmt
Industrial and/or contract property management
Manufacturing, production and quality assurance
Purchasing



Information Trade Space



After Law and Kelton

Identified Gaps

As a result of the Gap Analysis we conducted, four gaps were found in the area of workforce development:

- Lack of clearly articulated competency statements.
- Lack of a widely accepted disciplinary specification or body of knowledge.
- Lack of structured implementation of training and education vehicles.
- Lack of a widely applied process for certifying professionals based on a community-accepted disciplinary specification.

High Level ESR Development

- Process:
  - Initial list of ESR's developed by stakeholders and NPS inter-disciplinary team.
  - Stakeholders involved in iterative process to expand and refine ESR's.
- Results:
  - 17 Process ESR's –Focused on the process of choosing when to use which models and simulations.
  - 9 Acquisition ESR's –Focused on applying M&S in the acquisition lifecycle.
  - 5 Test and Evaluation ESR's –Focused on the role and use of M&S in test and evaluation.
  - 5 Operational ESR's –Focused on the use of operational and logistic M&S to support Acquisition/T&E activities.
  - 14 Engineering ESR's –Focused on the use of engineering models to support Acquisition/T&E activities.

Sample ESRs of all Disciplines

P1) Understand the critical decisions in the acquisition lifecycle, the analysis plans to support them, and the information required.

A2) Understand the concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle, in order to reduce the time, resources, and risks associated with the acquisition process.

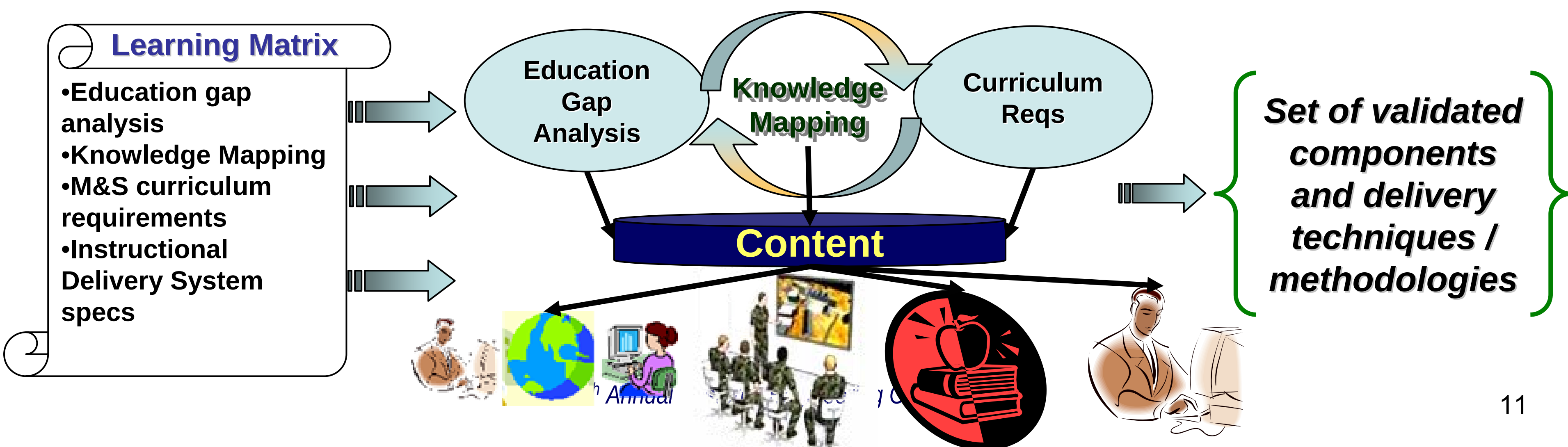
T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent testing decision.

O4) Understand abstractions and lower levels of realism in operational and logistics models.

E2) Fluid Dynamics and Weapon System - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

Spiral Two: Component Development

- <u>Emphasis:</u> Use the Learning Matrix to create necessary components for delivering training
  - Content
  - Instructional delivery technologies
  - Enable reuse and scalability
- <u>Methods will include:</u>
  - Blending SE with ISD
  - Design, Develop, Implement and Test components
- <u>Deliverables</u>:
  - Validated system components
    - Content
    - Delivery methods
  - Learning Architecture Framework to support integration

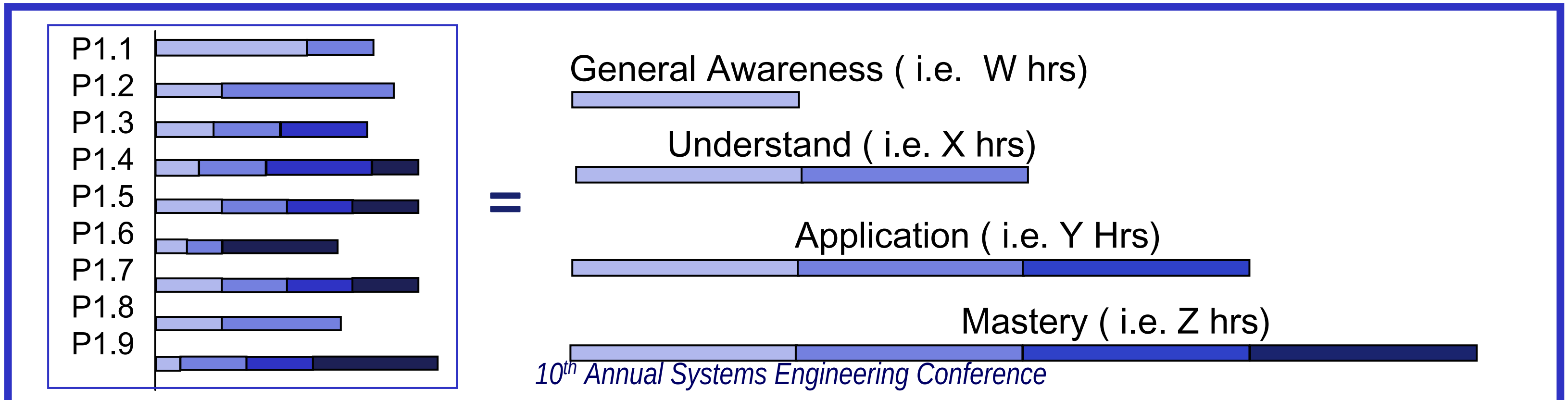


Academic Partners

- Air Force Institute of Technology
- Defense Acquisition University
- George Mason University
- Johns Hopkins University/ Applied Physics Lab
- Old Dominion University
- Stevens Institute
- Texas A&M
- University of California, San Diego
- University of Central Florida

Course/Module Concept

- Goal – Develop Course/Module "Syllabi"
  - Syllabi outline desired content of educational elements that will satisfy the needs identified in the Learning Matrix.
  - Syllabi combined into a consolidated and cohesive Learning Architecture.
- Each module developed to highest level of competency required for the subject matter (not always mastery)
- Modules constructed so that slices of the content can be extracted for lower required competency levels
- Courses built to target audience
  - Desired length of courses and competency levels required determine subset of modules combined into course structure
  - Human Capital Strategy survey feedback will help guide requirements.



Workforce Mapping

- Mapping of ESRs to workforce needs (Learning Matrix)
- Performed by Academic Partners, including GMU, JHU/APL, ODU, UAH, UCF, and UCSD
- Three pieces provided to complete mapping:
  - Workforce segmentation definitions
    - Career Fields - Project Managers, Systems Engineers, and T&E workforce
    - Career Levels - Basic/entry, intermediate/journeyman, and advanced/senior career levels
    - Follows DoD 5000.52M descriptions
  - Competence Levels
    - Four competence levels defined and mapped to Bloom's taxonomy – General Awareness, Understand, Application, and Mastery
  - Detailed ESR's – High level ESR's decomposed into "mappable" level of granularity

Program Management

- Positions Held:
  - All of functions of a PMO or PEO
  - Program integrators and analysts, program managers, PEOs, and deputies
  - Support and management positions throughout the workforce
- Responsibilities:
  - Balance the factors that influence cost, schedule, and performance
  - Interpret and tailor application of the DoD 5000 Series regulations
  - Ensure that high-quality, affordable, supportable, and effective defense systems are delivered to the warfighter as quickly as possible

PM Career Levels

- Basic/Entry
  - Member working in PM support role
  - Example jobs include R&D coordinator, test officer staff officer, integrator, analyst, etc.
- Intermediate/Journeyman
  - Managers of PEO/PMO office functions
  - Deputy PM or PM for small programs, PEO staff roles
- Advanced/Senior
  - ACAT 1 or 2 PM, PEO

Competence Levels

Competence Level	**Bloom's Taxonomy**	**Definition**	**Examples and Keywords**
General Awareness	Knowledge	Recall or recognize data or information.	**Examples:** Recite a policy. Quote prices from memory to a customer. Knows the safety rules. **Keywords:** defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.
Understand	Comprehension	Understand the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words.	**Examples:** Rewrites the principles of test writing. Explain in one's own words the steps for performing a complex task. Translates an equation into a computer spreadsheet. **Keywords:** comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives Examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
Application	Application	Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place. Put theory into practice, use knowledge in response to real circumstances	**Examples:** Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test. **Keywords:** applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses.

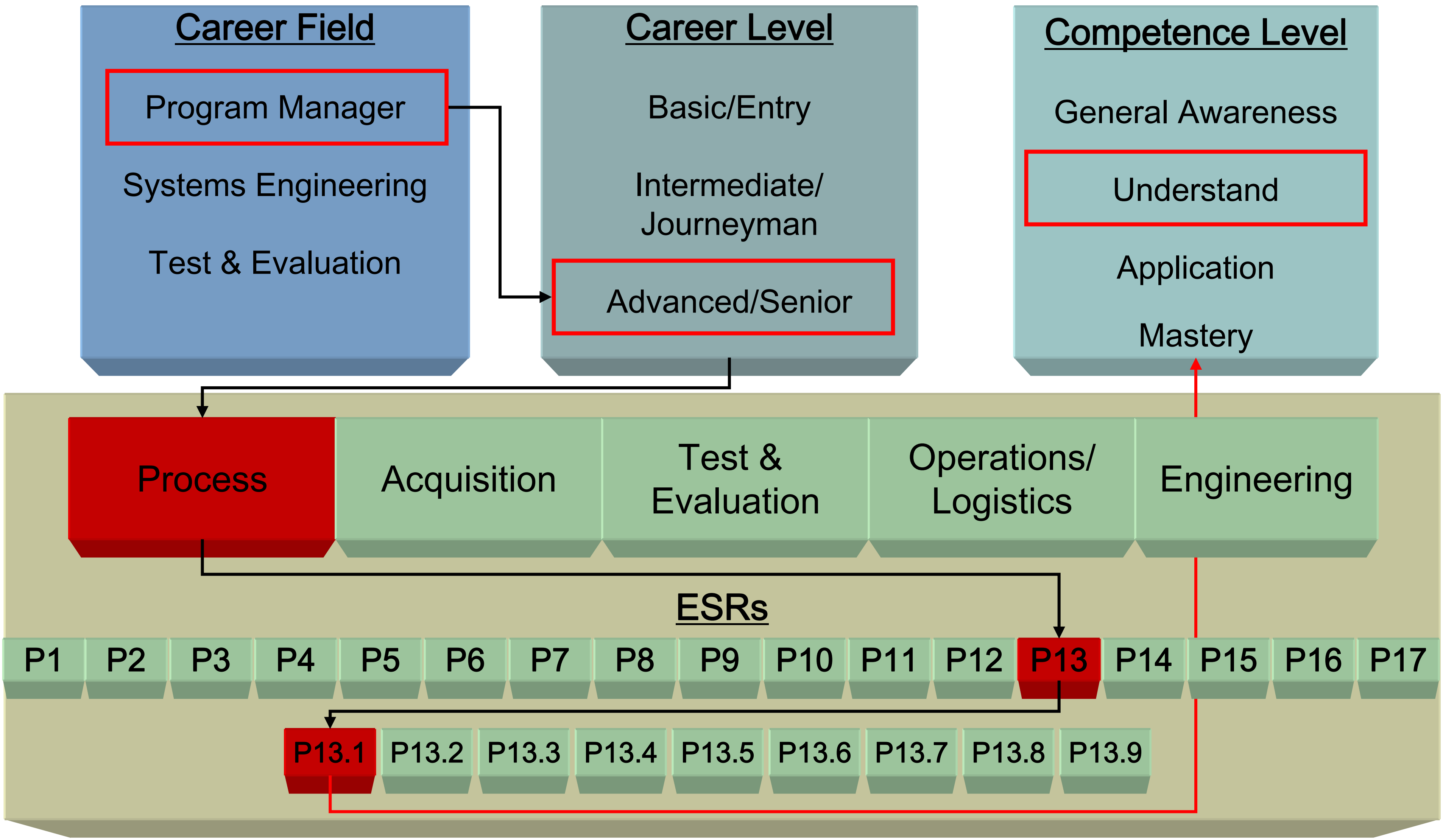
References:
http://www.nwlink.com/~donclark/hrd/bloom.html
http://faculty.washington.edu/krumme/guides/bloom1.html
http://www.businessballs.com/bloomstaxonomyoflearningdomains.htm

Competence Levels

Competence Level	Bloom's Taxonomy	Definition	Examples and Keywords
Mastery	Analysis	Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	**Examples:** Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training. **Keywords:** analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.
	Synthesis	Builds/develops new structures, systems, models, approaches, or patterns from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	**Examples:** Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome. **Keywords:** categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes.
	Evaluation	Make judgments about the value of ideas or materials. Assess effectiveness of whole concepts in relation to values, outputs, efficacy, viability; critical thinking, strategic comparison and review.	**Examples:** Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget. **Keywords:** appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports.

References:
http://www.nwlink.com/~donclark/hrd/bloom.html
http://faculty.washington.edu/krumme/guides/bloom1.html
http://www.businessballs.com/bloomstaxonomyoflearningdomains.htm

Path to Focused Learning



Workforce Mapping Example

Learning Matrix for one ESR (of 50)

	P13: Understand the trades between using a general model and a custom model, including the VV&A implications.								
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9
PM									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Mastery	Mastery
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE									
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Applica					
Advanced	Understand	Application	Application	Applica					
T&E									
Basic	Understand	Understand	Understand	Unders					
Intermediate	Understand	Application	Application	Applica					
Advanced	Understand	Application	Application	Applica					

P13.1 Define general model and custom model
P13.2 State advantages of general model
P13.3 State disadvantages of general model
P13.4 State advantages of custom model
P13.5 State disadvantages of custom model
P13.6 State VVA requirements of general model
P13.7 State VVA requirements of custom model
P13.8 Describe situations where each type of model is more appropriate
P13.9 Given historical examples of each, describe and analyze which is more appropriate

Way Forward

- Spiral Three – Course Development
  - Capitalize on Academic Partner Experience & Assets
  - Continue to integrate Stakeholder feedback
  - Ensure flexibility in course design through modular concept (plug and play)
- Spiral Four – Education Program Deployment
  - Test Courses with student/sponsor feedback
  - Implementation of Continuous Assessment Tool

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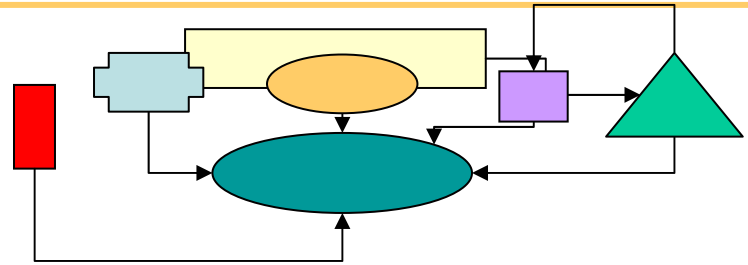
Questions?

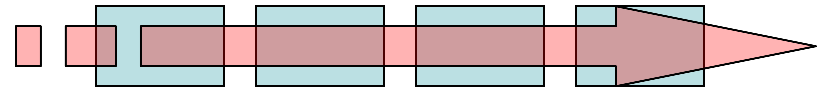
Backup Slides

Curriculum Design

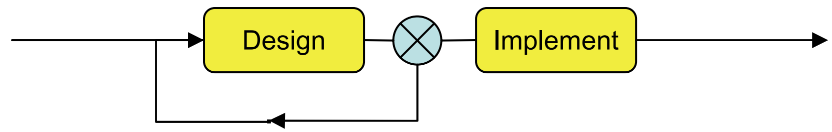
- Many choices exist
  - Ad Hoc Approach



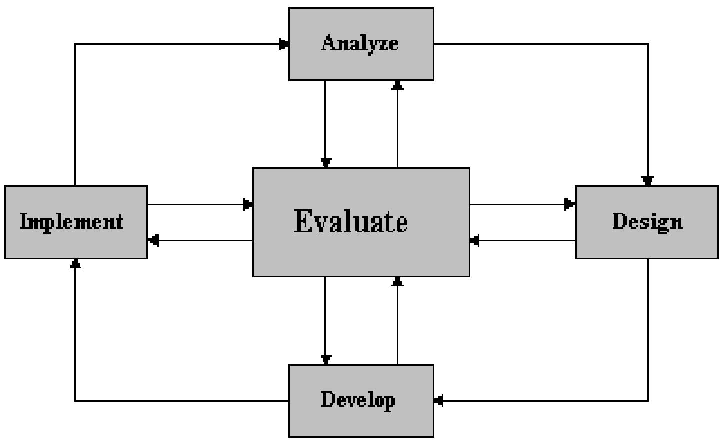
  - Linear Process



  - Feedback Loop Driven

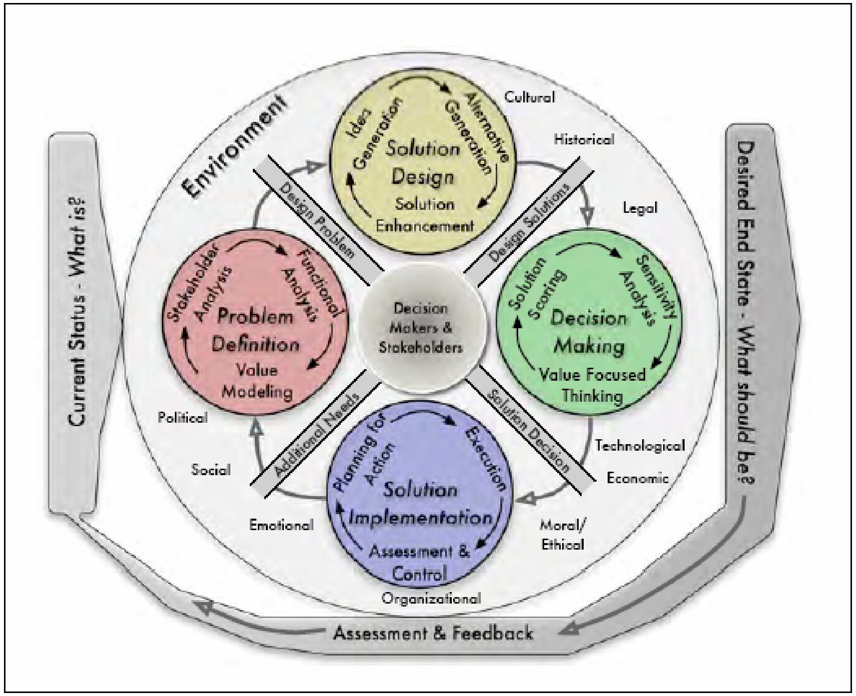


  - Systems Engineering Approach
  - Instructional System Design
    - ADDIE phases



Systems Engineering

- Familiar SE Models
  - Vee
  - Waterfall
  - Spiral
- Five common items to all
  - Top-down view of entire system
  - Life-cycle approach
  - Ensure requirements are right
  - Iterate using feedback loop
  - Use interdisciplinary approach

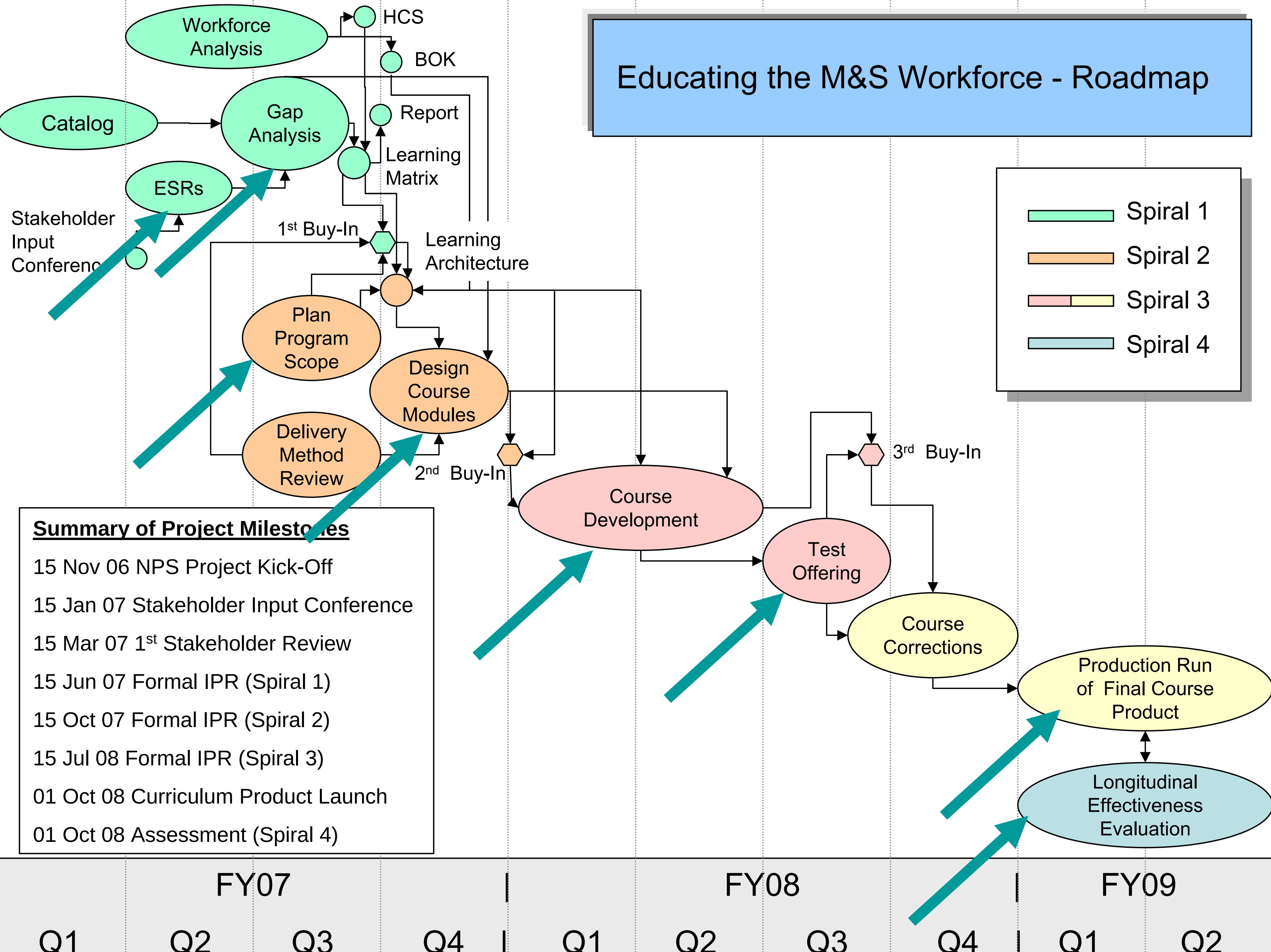


US Military Academy Approach

Project Overview

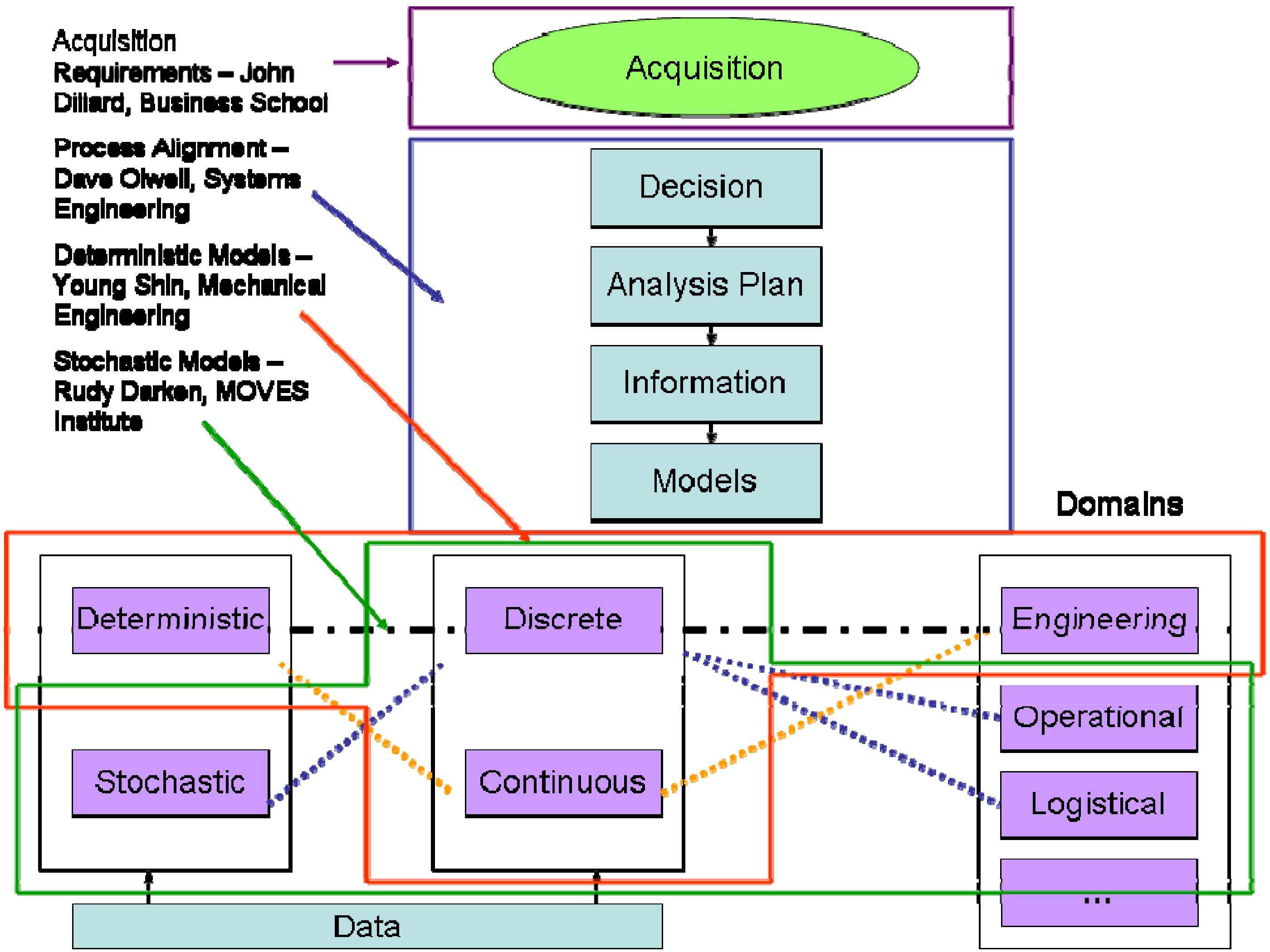
4 Spirals (Phases) make up the Project

1. Learning Matrix
   - Desired instructional content based on ESRs for Acquisition workforce
   - Integrates educational background, learning style, workforce role, and desired education end state
   - M&S Workforce Education Gap Analysis
2. Learning Architecture/Instructional Framework
   - Degree/certificate programs and continuous learning modules
   - Content modules (course syllabi)
3. Prototype Curriculum
   - Develop curriculum from content architecture
   - Deliver with endorsement/accreditation to DAU, NPS and services
4. Assessment
   - Longitudinal Curriculum Effectiveness Evaluation

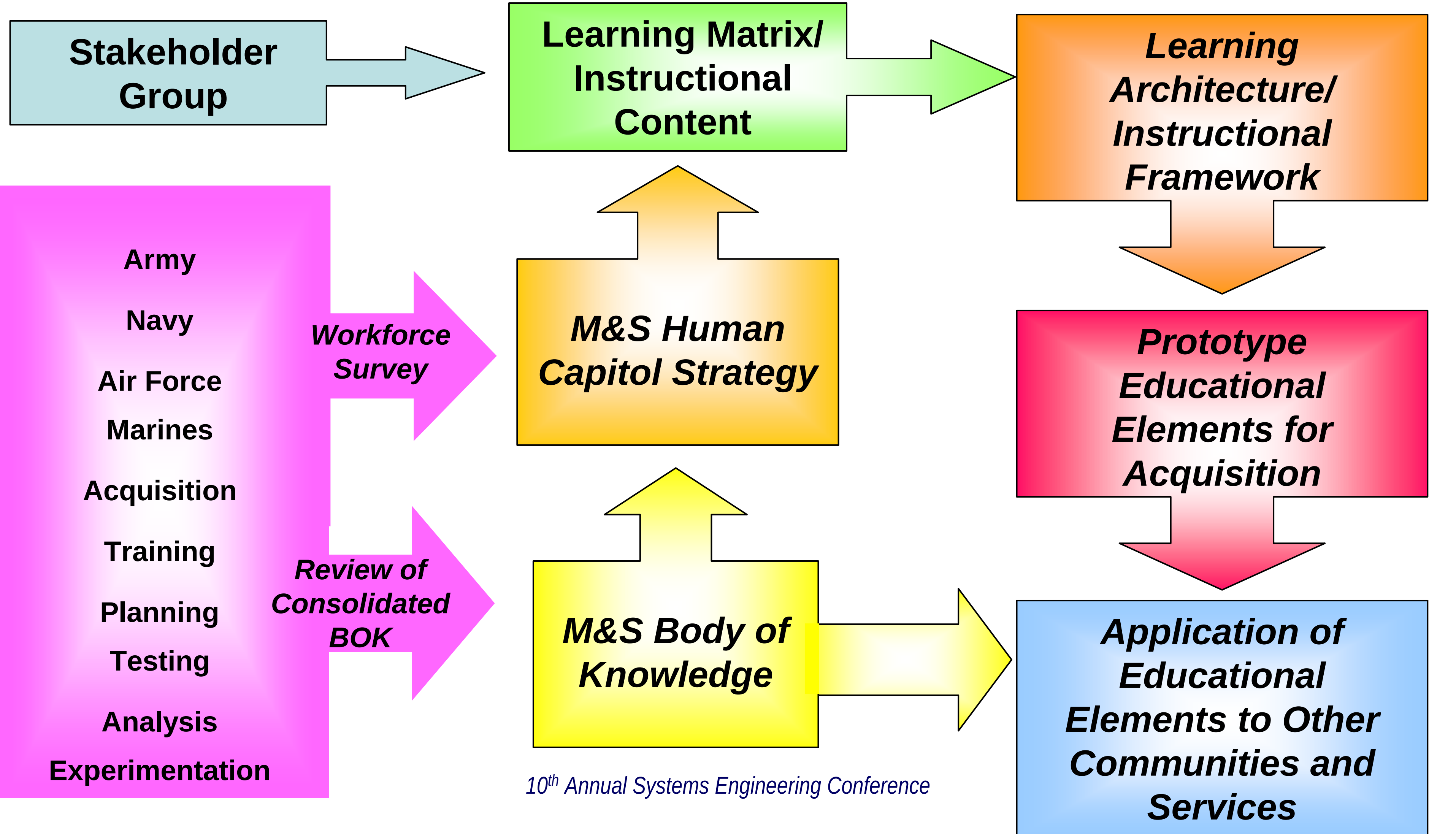


Educating the M&S Workforce - Roadmap
Workforce Analysis
HCS
BOK
Catalog
Gap Analysis
Report
Learning Matrix
ESRs
Stakeholder Input Conference
1st Buy-In
Learning Architecture
Plan Program Scope
Design Course Modules
Delivery Method Review
2nd Buy-In
Course Development
3rd Buy-In
Test Offering
Course Corrections
Production Run of Final Course Product
Longitudinal Effectiveness Evaluation
Spiral 1
Spiral 2
Spiral 3
Spiral 4
Summary of Project Milestones
15 Nov 06 NPS Project Kick-Off
15 Jan 07 Stakeholder Input Conference
15 Mar 07 1st Stakeholder Review
15 Jun 07 Formal IPR (Spiral 1)
15 Oct 07 Formal IPR (Spiral 2)
15 Jul 08 Formal IPR (Spiral 3)
01 Oct 08 Curriculum Product Launch
01 Oct 08 Assessment (Spiral 4)
FY07
FY08
FY09
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2

Decomposition of Model Types



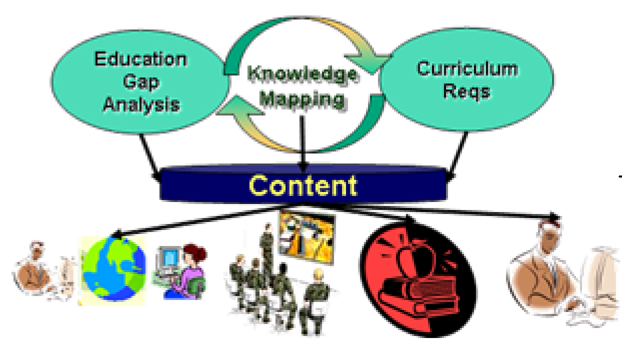
Tying it all Together

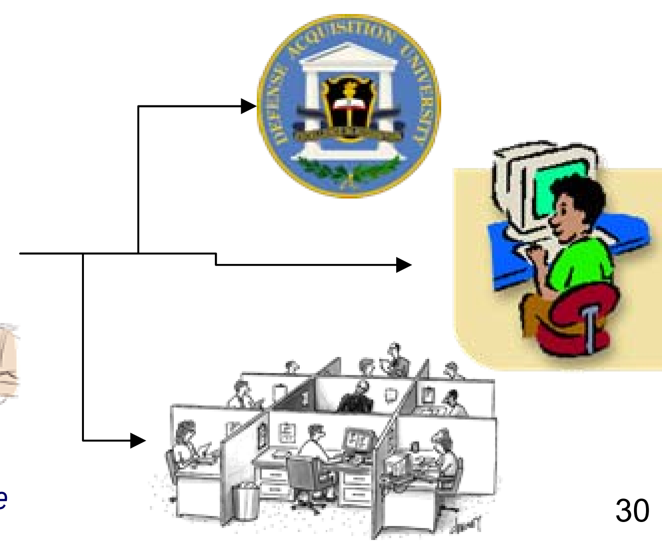


Spiral Three: System Integration and Delivery

- Emphasis: Spiral three will create prototype curriculum
  - Modeled after other DAU courses like the Acquisition courses which have on line and schoolhouse components based on user's career needs
- Methods: The curriculum will
  - Provide tailorable learning modules
  - Support various accreditation approaches
  - Leverage distance learning and schoolhouse instructional paradigms.
- Deliverable: Instruction provided through existing DoD channels identified in conjunction with DAU

Spiral 3 will produce validated, reusable course content that can be accessed by individuals at various stages of career development

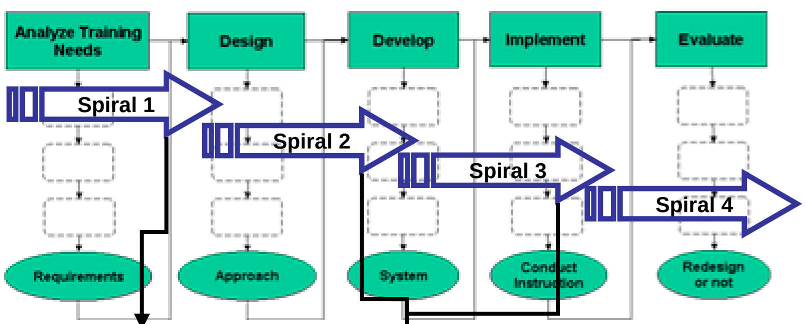




Spiral Four: Longitudinal Curriculum Effectiveness Evaluation

- Emphasis: Spiral four will provide assessment and validation of the long term impact of the curriculum
- Methods: Base evaluation on Kirkpatrick's 'four levels'
- Deliverable:
  - Measurement of the degree to which this approach enhances performance
  - Suggestions for enhancements and modifications

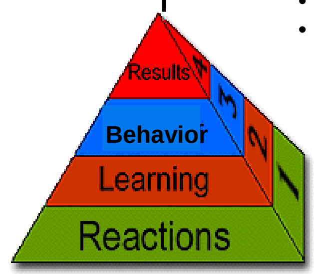
Using ISD, evaluation cuts across all Spirals, but in different ways



Integrated Feasibility Assessment 1
- SME Review

Integrated Feasibility Assessment 2-3
- SME Review
- Iterative Usability

Kirkpatrick's 4
- Reactions
- Learning
- Behavior
- Results



Results (impact on bottom line):
- Increased productivity
- Improved quality
- Reduced costs

Behavior:
- Are KSAs being used in the work environment?

Learning:
- Were desired KSAs advanced and internalized?
- Use Pre/Post paradigm

Reactions:
- How did students like the program?
- Did it address perceived needs?
- How would they change it?

http://coe.sdsu.edu/eet/articles/k4levels/index.htm

Application of Systems Engineering Principles in the Design of Acquisition Workforce Curricula

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ABSTRACT

The Navy M&S Office in conjunction with the Defense Acquisition Modeling and Simulation Working Group presented the Naval Postgraduate School with an enormous challenge in 2006: design and deliver an educational program by 2008, for 20,000 or more acquisition professionals, focusing on the effective use of modeling and simulation in acquisition. The acquisition workforce is central to force transformation, and education is the key to transforming that workforce. This paper describes the processes, lessons learned to date, and assessment plan for this project.

We applied a systems engineering approach to the problem of curricular design. The resulting solution consists of four spirals. The first spiral focused on defining the problem. We developed our analysis based on factors such as our market segmentation of the acquisition workforce, the current resources available, the state of the modeling and simulation body of knowledge, the desired educational outcomes for each market segment, and the gaps that existed between those outcomes and the existing resources. At each step in the process, we involved key stakeholders from the acquisition, test and evaluation and training communities. We describe the results of this process.

In the second spiral, our goal was to construct a learning architecture to cover the gaps identified in the first spiral. We describe the course content, scope, and delivery methods that we determined based on those needs from the first spiral.

The results of the first and second spirals, and subsequent lessons learned, will be the focus of our discussion herein. We will also briefly summarize the third and fourth spirals, which are currently underway, that involve course design and testing in the case of spiral three, and delivery and assessment of the curriculum for spiral four.

ABOUT THE AUTHORS

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INTRODUCTION

The Department of Defense Modeling and Simulation (M&S) and Acquisition communities recognize the need for education and training in M&S across the acquisition workforce (DoD M&S CO, 2006). The desired educational program is different than existing educational opportunities in that it targets *users* of M&S rather than *developers*.

To meet this need, the Naval Postgraduate School applied a systems engineering approach to develop a set of curricula. We submit that this is different from traditional curricular design in that it enables the production of a better suited end product by incorporating systems engineering principles that are not inherent in typical curriculum development projects. In particular, the focus on requirements elicitation from external stakeholders and requirements analysis presents a unique emphasis.

The design process incorporated several institutions that agreed to deliver a common set of curricula to meet the needs of the Defense community. This, too, is an uncommon practice in curricular development.

This paper reports our progress as we near the end of the first year of this multiyear program. It contains a description of the process and of the deliverables produced during the first phase. Further papers will describe the results of the curricular development implementation of later phases of that process.

Herein we will first provide a brief overview of curriculum design and systems engineering approaches. Then we will show how we applied these systems engineering approaches to the design of a set of modeling and simulation curricula. We present the requirements that our process defined. We sketch our future work to complete this project. Finally, we will provide some lessons learned.

CURRICULUM DESIGN

Traditional curriculum design approaches vary from ad hoc construction of materials to systemic Instructional System Design (ISD) approaches that generally follow the ADDIE model: analyze, design, develop, implement, and evaluate (Molenda, 2003). This has been characterized as an inherently linear process (Bell and Lefoe, 1998). Other advocates characterize it as a feedback

loop. For example, Don Clark (2006) presents the flowchart in Figure 1 to characterize ISD. Clark also presents a detailed breakdown of the tasks to be performed in each of the five phases of ADDIE.

Iterative design process appears in the literature. Bell and Lefoe propose a feedback loop in their outcomes based on integrative and flexible delivery models. Walkington (2002) proposes a similar feedback cycle. However, most curricular development is sufficiently challenging that institutions settle for a single pass through the design cycle. For example, the Electrical and Computer Engineering Department at Carnegie Mellon spent four years on a single redesign of its curriculum (Director et al., 1995).

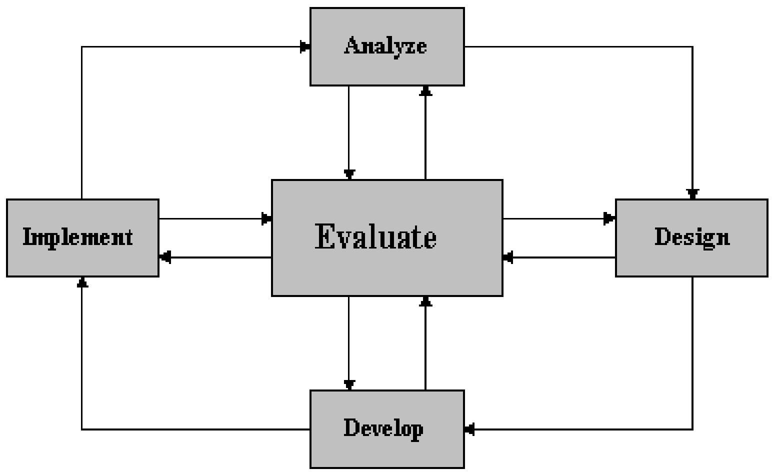

Figure 1: ADDIE model of Instructional Design, as a flowchart. Adapted from Clark (2006).

Engineering accreditation is beginning to demand evidence of involvement from constituents in the design and development of engineering curricula. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) seeks "high degree of involvement in defining objectives and desired outcomes, assessment, and improvement cycles; (and) sustained evidence of strategic partnership with all key constituents." (ABET, 2002) The ABET is also pressing for evidence of feedback loops in curriculum revision.

At our own institution, curricular design incorporates a strong involvement from constituents (called "sponsors" at NPS) in the services and also a biennial curricular review process involving constituents (NPS, 2003). We have also participated in a multi-school educational franchise, called "Product Development for the 21st Century." This curriculum was jointly developed and delivered by NPS, MIT, RPI, and the University of Detroit – Mercy. All of the partners deliver the same courses, using a common set of syllabi.

Emerging best practices, then, favor strong constituent input, feedback loops, and detailed work breakdown. These desired characteristics lend themselves well to the choice of a Systems Engineering (SE) methodology as a practical approach to curriculum design.

SYSTEMS ENGINEERING APPROACH

As a systems engineering department, we approached this project inside the framework of our traditional SE design models. Several models representing the systems engineering process exist (Blanchard and Fabrycky, 1998). They hold several principles in common. First, take a top - down approach that views the system as a whole. Second, take a life-cycle approach that addresses all the phases of the system life in the design process. Third, get the requirements right at the start of the project. This involves careful coordination with stakeholders. Fourth, iterate using feedback loops. Last, use an interdisciplinary approach. The waterfall, spiral, and Vee methods all have these five points in common.

We use an approach similar to the one developed at the US Military Academy, presented here as Figure 2. We adapted these principles in our approach to the design of these curricula.

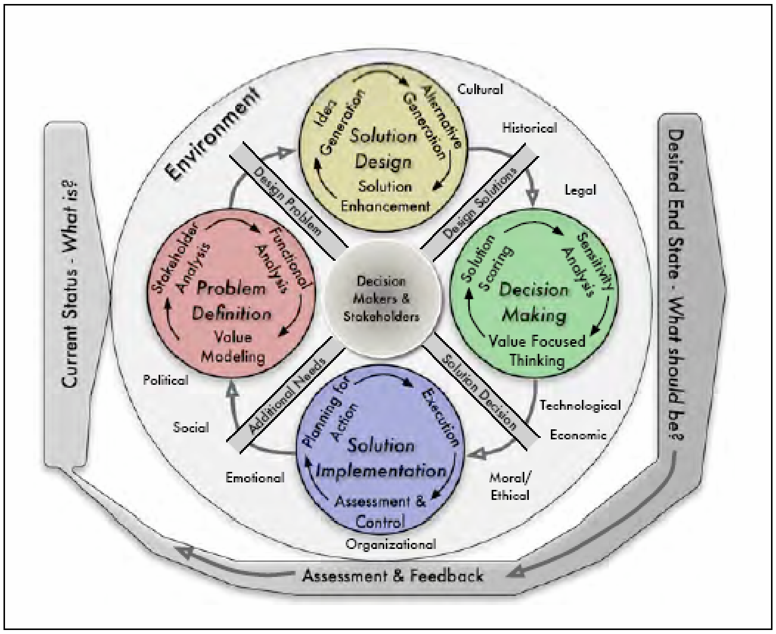

Figure 2: Systems engineering design process. From Parnell, Driscoll, and Henderson (2006).

In keeping with the SE design process concept, we took a top-down look at the problem. We segmented the target student population by career field and level of expertise. Next we scoped the project to address three of the thirteen acquisition career fields. They were program managers, system engineers, and test & evaluators. The three levels of expertise established for each of these career fields were basic/entry, intermediate/journeyman, and advanced/senior. These were also in alignment with the career levels defined by DoD Instruction 5000.52M (DoD, 1995). We determined the educational requirements for each of these nine (three by three) audiences. We examined what was available nationally to meet these educational requirements, and defined the gaps. We then determined the requirements to design various content modules to address those gaps. This differs from a bottom-up approach, which would have assembled existing courses into a program.

We took a life-cycle approach to the design of the curricula, focusing on assessment and feedback mechanisms. We found that designing the business plan to support the delivery of the curricula presented the biggest challenge. This is discussed in the lessons learned portion of this paper. We took great pains to get the requirements correctly defined. This, too, is discussed in detail in a subsequent section. We have planned for iteration in the design of the program, using a test-fix-test paradigm.

Last, we assembled an eclectic team of instructors from many disciplines and institutions, practitioners, educational designers, representatives of the user community, along with representatives of industry. The requirements defined have been reviewed and accepted by this broad-based team.

Next we developed a project plan for the development of the curricula. It is organized into four spirals, presented graphically in Figure 3. The first spiral consists of requirements definition, the second is development of the architecture, the third is detail design and development, and the fourth is delivery and assessment. As of the writing of this paper, spiral one is complete and we are nearly complete with spiral two.

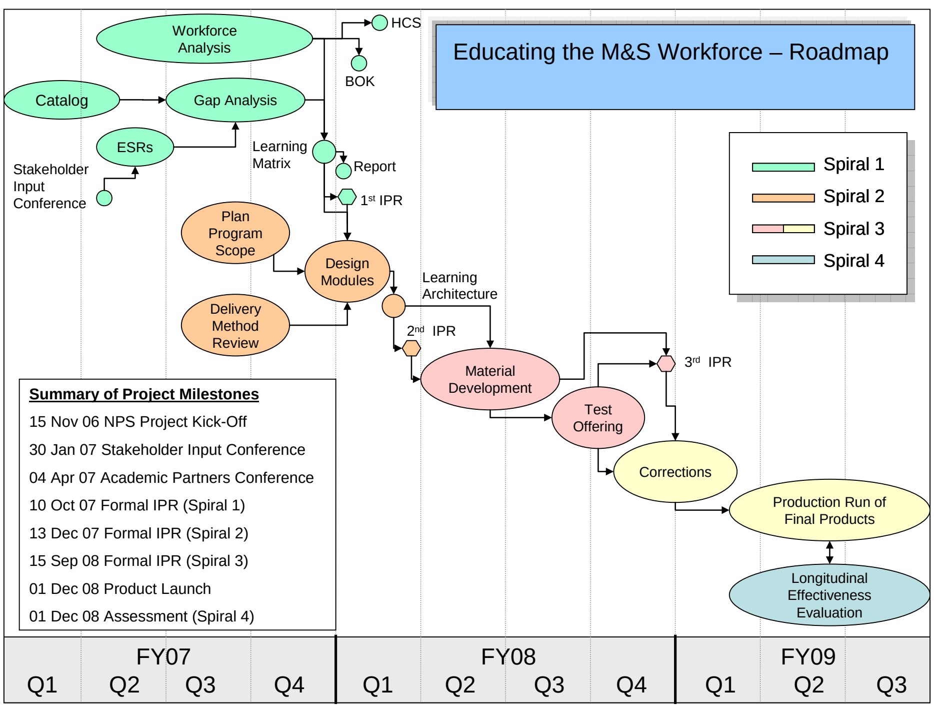

Figure 3: Project plan.

How does our approach differ from traditional instructional systems design? In many ways, it is similar. Top-down approach, analysis of requirements, and feedback loops are elements of ISD. What distinguishes our approach is a matter of emphasis on requirements, the interdisciplinary nature of the subject matter and hence of the partners, and the life-cycle planning.

In our SE model, we are now in the Solution Design Phase, having recently completed the Problem Definition Phase, with its emphasis on stakeholder analysis, functional analysis, and value modeling. Since our curricular design answers to and must be approved by a set of external customers, this problem differs from the traditional curricular design where the decision makers reside in the institution delivering the instruction. This, coupled with the necessity for building consensus for design and delivery across a wide set of academic institutions, has driven us to use a systems engineering paradigm over an ADDIE paradigm.

SPIRAL ONE

The first spiral began in November 2006. We assembled a team at NPS from the engineering school, the school of operational sciences, and the business school to explore how we would build an interdisciplinary and inter-departmental team to address the request of the sponsor. Most schools find team building across such a range of disciplines and institutional boundaries challenging, and our school is no different. We agreed on a structure for organization, and agreed to partition the work for parallel development, with a small steering committee responsible for organization and integration.

We set a small team to work collecting data on existing educational programs that might address, fully or partially, the education of acquisition personnel to employ modeling and simulation in their projects. This resulted in a catalog of existing programs in a relational database.

Concurrently, we set up another team to develop the detailed educational requirements for each of the nine market segments. Following terminology used at NPS, we called them “Educational Skill Requirements” or ESRs for short. We identified key representatives from the user communities in government and industry. We also identified a set of potential academic partners for delivery and involved them in the requirement setting. The ESRs were broken into five areas which are presented below.

We compared the results of the ESRs with the catalog, and identified the key gaps extant. Those gaps are presented and discussed below. And finally, we organized the audiences, ESRs, existing programs, and gaps into a “learning matrix.” This single document summarized the requirements for the curricula to address each segment.

Concurrent In parallel with our work, partners at the Air Force Agency for Modeling and Simulation were developing a human capital strategy for the modeling and simulation community, and defining a body of knowledge for that group of professionals. Their work complemented ours by addressing a different portion of the defense workforce.

CATALOG

The catalog contains data from 22 institutions that offer relevant instruction. It contains information about 253 courses. The data is organized into tables, including institution, programs, courses, topics, learning objectives. Cost data and delivery options are included. The

catalog allows the team to search for courses that meet the proposed ESRs, and to then refine the search by parameters such as cost, delivery method, duration, and location.

The focus of existing education is on those who develop and analyze models and simulations. There are few courses that focus on those acquisitions professionals who are supported by M&S efforts. Catalano and Didoszak (2007) found "Existing post-graduate modeling and simulation degree programs produce engineers capable of developing M&S, rather than focus on the required knowledge to *use* the M&S for acquisition." They found 29 courses that had an acquisition focus and that targeted acquisition professionals. These were in most part "short introductory courses of a few days in length providing a basic understanding of the use of M&S" (Catalano and Didoszak, 2007). There were only nine of 188 traditional courses that addressed any of the objectives of the new program. They also found that the average cost per course was $1271.

EDUCATIONAL SKILL REQUIREMENTS

After consulting with our stakeholders, we broke the ESRs into five groups: process, program management, operations and logistics, test and evaluation, and engineering. The first group addressed common M&S issues for the acquisition community, and the last four addressed issues that focused on the corresponding domains of application.

The process ESRs are presented in Table 1. These ESRs have been vetted by users, sponsors, industry, academic partners and other stakeholders. There is wide agreement that they are comprehensive in scope. The rest of our ESR groups focus on the domains of application. Those ESRs are listed in Tables 2 - 5.

Table 1: Process ESRs

P1) Understand the critical decisions in the acquisition lifecycle, the analysis plans to support them, and the information required.
P2) Understand the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps, and to estimate how well new program concepts might address those gaps.
P3) Understand the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.
P4) Know the technical aspects of the domain of application.
P5) Know the taxonomy and hierarchies of models and simulations and be able to select appropriately for a given situation. Understand the types of architectures and role of architectures in tying together and communicating requirements, analysis, modeling and simulation, design, and development planning to all stakeholders. Understand how M&S is deployed in different environments (Live, Virtual, and Constructive). Understand the differences between standalone and confederated M&S applications and when to apply each in various situations. Be familiar with the simulation interoperability standards.
P6) Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of "built to" or "buy to" performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.
P7) Estimate the cost, develop a schedule, and measure the performance of a modeling and

simulation plan. Identify the areas of risk and develop a mitigation strategy. P8) Know how to incorporate modeling and simulation, through a Simulation Support Plan, into a systems engineering plan and a test and evaluation master plan. P9) Know and require the best practices and standards in modeling and simulation as developed in key case studies. P10) Know the models and simulations used in a given domain, their inputs and outputs, and their strengths and weaknesses. P11) Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD. P12) Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model. P13) Understand the trades between using a general model and a custom model, including the VV&A implications. P14) Design a sound simulation study for a given set of objectives. P15) Apply appropriate statistical techniques to the analysis of simulation output. P16) Know how to manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse. P17) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

Table 2: Program Manager ESRs

A1) Understand the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with respect to design, testing, training, production, cost estimation, manning, and logistical simulations. A2) Understand the concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle, in order to reduce the time, resources, and risks associated with the acquisition process. A3) Be able to discern among M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose. A4) Understand the role of M&S in the contract proposal process, how M&S efforts will be defined and specified, and the value of M&S deliverables under an acquisition contract. Determine their need for continuous improvement, vis-à-vis M&S cost/benefit trades throughout the program life cycle. A5) Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, and how they might be leveraged in support of an acquisition program. A6) Be aware of the Modeling and Simulation Resource Repository as a single source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication. A7) Understand experimental design, level of model detail, and M&S application as a pre-test prediction tool. Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Understand the analysis of M&S outputs/measures. A8) Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E) – particularly operational and live-fire test and evaluation. A9) Know how to employ M&S to explore reliability and interoperability issues.

Table 3: Test and evaluation ESRs

T1) Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration. T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent testing decision. T3) Understand the different types of testing (i.e. unit, integration, interoperability, and operational) and identify the utility, limitations and risks for use of M&S in each. T4) Understand the potential opportunities for employing M&S in the test planning and execution process. T5) Be aware of existing M&S T&E facilities used within the DoD.

Table 4: Operational and logistical modeling ESRs

O1) Understand the role of operational and logistical models in the acquisition life cycle and when they are used. O2) Know the properties of a representative suite of operational models across the services, including required inputs, outputs, assumptions, implementation requirements, costs, time required, adaptability and extensibility, and VVA status. O3) Know the properties of a representative suite of logistical models across the services, including required inputs, outputs, assumptions, implementation requirements, costs, time required, adaptability and extensibility, and VVA status. O4) Understand abstractions and lower levels of realism in operational and logistics models. O5) Understand and be able to model the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies.

Table 5: Engineering ESRs

Depending on the system being acquired, a <u>particular subset</u> of these may apply: E1) Structural Mechanics, Shock and Vibrations - Understand basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S. E2) Fluid Dynamics and Weapon System - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects. E3) Dynamics and Control - Understand the basics of M&S in process and multi-physics (mechanical, electrical & hydraulic) based dynamic system controls. E4) Thermodynamics and Heat Transfer - Understand the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design. E5) Materials and Fabrication - Possess a basic understanding of the materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S. E6) Acoustic and Electromagnetic Systems - Have a general awareness of the fundamentals of acoustic and electromagnetic wave propagation and application to DoD systems. E7) Military Platform Systems Engineering - Appreciate the broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems. E8) Computers - Recognize basic computer system architecture, operating systems, networking

and introduction to engineering software and their applications. Possess at least a limited proficiency in a structured programming language such as Fortran or C, and be able to use such tools for code development. Gain exposure to finite element/difference codes, with application to solve engineering problems including experience with selected software packages.
E9) Electrical Engineering - Understand basic circuit analysis including DC and AC circuits. Gain an exposure to the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.
E10) C4ISR - Understand the requirement for Command, Control, Communications Computers, Intelligence, Surveillance and Reconnaissance in systems. Understand the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Have the ability to analyze all available technologies for achieving rapid/effective/jam-resistant information transfer.
E11) Networks - Understand the principles of networks applied to military applications including physical, command and control, and social networks and their implications for engineering design of system
E12) Environment - Understand the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to describe how systems interact with and are influenced by their environment.
E13) Human Systems Integration - Understand the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.
E14) Aerodynamics - Understand the principles of aerodynamics with applications to M&S. Understand the cost, schedule, and iterative development nature of simulation testbeds used for flight software development through formal qualification.

These process ESRs contain several noteworthy tasks. They indicate that the integration of modeling and simulation as a source of data into formal decision making processes remains an important challenge for acquisition professionals. P5 requires the appropriate selection of a model and simulation for a given situation. P6 requires the student to establish and write valid modeling and simulation requirements. P7 requires the student to demonstrate project management skills for M&S activities, including cost estimation, scheduling, performance assessment, and risk identification and mitigation. There was wide consensus that the skills and knowledge identified in the process ESRs were vital, and that it was of great importance to deliver these widely throughout the M&S workforce.

The engineering ESRs in Table 5 also deserve special comment. We observed that many in the acquisition community had a greater familiarity with operational models than with engineering models. Operational models are useful for verifying that the correct set of capabilities is defined in the concept development phase. Engineering models are useful for design, and especially for testing. In fact, if one desires to substitute M&S results for live testing, one is most often contemplating the use of an engineering model.

After long discussion and careful consideration of the audience, we decided that formal survey courses on the principles listed in Table 5 was not going to be palatable to the general members of the acquisition community, who lacked the time and background to complete them successfully.

We decided to address the engineering ESRs through a set of case studies that provide the engineering context as they presented the case. Accordingly, we commissioned preliminary

design of eleven case studies. These range from the dynamics and control theory underlying the Segway machine, to the structural mechanics, fluid mechanics, and environmental science behind ship shock simulation models.

RESULTS OF GAP ANALYSIS

The gap analysis revealed two main gaps. First, where there were courses and material that addressed the ESRs, there was no common look and feel to them. In their current state, they cannot be easily integrated into a coherent whole. For example, the Defense Acquisition University has a module on M&S for System Engineering (DAU, 2006) that is delivered on-line. A second short course is offered by George Mason University in a three day, 21 hour short-course delivered in traditional lecture format. These courses cover some of the ESRs but not at the depth necessary for some of the audiences. It is not possible to integrate the two courses as they exist as they were not designed for such integration and since they use different modes of delivery.

The second main gap was that a number of key ESRs had no courses or materials that addressed them at the level desired for the acquisition professionals. This was particularly true of the engineering ESRs. It was also true for several of the program manager and process ESRs.

A detailed report on the gap analysis is available upon request to the authors.

PARTNERSHIP PROCESS

The target audience for these curricula is estimated at 20,000 students. This exceeds the capacity of any one educational institution. To address this, we recruited partner schools from across the nation to participate in the project. Partners as of this writing include: George Mason University, Johns Hopkins University / Applied Physics Lab, Old Dominion University, Stevens Institute of Technology, University of Alabama (Huntsville), University of California (San Diego), and the University of Central Florida. We have divided work among ourselves according to our specific competencies and strengths. For example, the University of Alabama (Huntsville) has a national reputation for its simulation based testing work, and that school volunteered to lead the design work for many of the T&E ESRs previously shown in Table 3.

We developed a metaphor for our approach. We consider ourselves a national food franchise chain. Together with the academic partners, we are designing a menu and a store layout. All the institutions can open their own franchise store, but the layout and menu will be standardized across the chain. Quality benchmarks and standardized syllabi will help assure that the product at one store is the functional equivalent of the product at any another store.

We have broad agreement on this approach, but as we have not yet completed design integration, the level of difficulty in bringing this approach into reality remains an open question.

STAKEHOLDER FEEDBACK

Our panel of stakeholders includes representation across the services. The Navy is represented by staff from the Secretary of the Navy's office, the Naval Air Systems Command, the Space and Naval Warfare Systems Command, and the Commander Operational Test and Evaluation Force. The Army is represented by staff from Headquarters, Department of the Army, and the Future Combat System Program Office. The Air Force is represented by the Air Force Agency for Modeling and Simulation and the Joint Strike Fighter Program Office. The Marine Corps has been represented by staff from the Expeditionary Fighting Vehicle Program Office. Industry has been represented by Boeing.

We have iterated the approach and the ESRs several times through the stakeholders to achieve consensus. We have also briefed the senior members of the Defense Modeling and Simulation Coordination Office on progress to date, and we have incorporated their feedback as part of our design process.

Major design reviews are scheduled at the end of each spiral with representatives of the stakeholders and the sponsors.

SPIRAL TWO

Our current spiral takes the results of our gap analysis and develops syllabi for content modules to address those gaps. The majority of this work is being performed by our academic partners and is nearly complete. Much of this work focuses on defining the detailed ESRs which will then in turn create the learning architecture through an index of specific tasks fulfilling the stated educational requirements. An example of what the detailed ESRs might look like for P13, one of the Process ESRs from Table 1, is shown in Figure 4.

Here the overarching ESR is decomposed into sublevel ESRs. The depth of knowledge for each of the career fields, at the accompanying career level, shown as you enter the table from the left, is defined by the general competence levels: General Awareness, Understand, Application and Mastery. Once complete, each of the 50 ESRs will have a corresponding table consisting of detailed ESRs mapped to the appropriate level of granularity. This then forms the consistent and cohesive structure of our learning architecture.

	P13: Understand the trades between using a general model and a custom model, including the VV&A implications.								
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9
PM									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Mastery	Mastery
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
SE									
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	App					
Advanced	Understand	Application	Application	App					
T&E									
Basic	Understand	Understand	Understand	Und					
Intermediate	Understand	Application	Application	App					
Advanced	Understand	Application	Application	App					

P13.1 Define general model and custom model
P13.2 State advantages of general model
P13.3 State disadvantages of general model
P13.4 State advantages of custom model
P13.5 State disadvantages of custom model
P13.6 State VVA requirements of general model
P13.7 State VVA requirements of custom model
P13.8 Describe situations where each type of model is more appropriate
P13.9 Given historical examples of each, describe and analyze which is more appropriate

Figure 4: Example of Sublevel ESRs and Corresponding Career Level Competencies.

While each module will be developed to the highest level of competency that is required for the subject matter, it may not necessarily be to the Mastery level. By implementing this kind of a methodology in the design of the course modules, portions of content containing more details information can later be extracted to meet lower required competency levels without a major overhaul of the course.

This concept allows for the flexibility in creating courses that are tailored to the target audience, one of the key stakeholder inputs stressed heavily during our early discussions on the deployment of this education program. Any number of desired competency levels, course lengths and delivery methods can then be combined to provide an optimized solution in educating the end user.

As expected, Spiral Two will conclude with a design review where our sponsors will approve the work prior to moving to the next stage.

WAY AHEAD: SUBSEQUENT SPIRALS

Our instructional design team at NPS will complete the templates for the "common look and feel" for the content modules. The engineering case studies that were previously mentioned will be one of the first deliverables and will serve as a first opportunity to "test market" our product. As theses case studies will be used to support the courses created in Spiral Three, we anticipate incorporating this initial feedback in early to make the greatest impact on the course development process.

At present we are planning a mixture of traditional academic courses, short courses, online courses, stand-alone reference material, and collections of case studies. We will confirm with our stakeholders the delivery methods that will be used.

As part of the life-cycle analysis, we will develop a long-term business model with our sponsors. The model will account for delivery, maintenance, and periodic update costs.

Spiral Three includes the actual development of the content modules and supporting materials. It includes a classroom test of the materials, and the generation of feedback on those materials from students, sponsors, and stakeholders. Following that feedback, one quarter is allocated for corrections to address any deficiencies and to disseminate any exceptional best practices.

Spiral Four is the production delivery and the longitudinal assessment of the effectiveness of the material.

A NOTE ON ASSESSMENT

Three separate assessment efforts are underway. The first is to assess student knowledge before and after completion of the content for his or her market segment. This involves a pre-test that will also be used to tailor material to the student. At the end of the curriculum, a post-test will assess the student's mastery of the educational skill requirements. The pre-test and post-test are being developed at NPS for web-delivery.

The second is an assessment of the appropriateness of the educational skill requirements. This will involve long-term surveys of both graduates and their employers for feedback on how useful the ESRs were in the performance of their duties.

The third assessment effort will focus on the effectiveness of the instruction and will be administered to students at the completion of each content module. This will be used to continuously improve the delivery of the information.

LESSONS LEARNED

Lessons learned to date are necessarily preliminary. Nonetheless, we have some initial findings. It has taken longer to build consensus among the wide group of stakeholders represented than we originally anticipated. Thus, the greater the number of partners, the less agile the effort becomes. There is an enormous amount of coordination and synchronization necessary in an undertaking such as this. This requires much greater management than we had anticipated. Obtaining consensus is also difficult when team members have different visions.

The business plan cannot be ignored when building curricula. When we started this project, the initial business plan was that the costs of delivery would be centrally funded. This changed to a customer-funded model as we got underway. The mechanics of that funding and revenue sharing are being worked out. Of greater importance, unless the workforce is presented with incentives to enroll in the curricula, there is a risk of low enrollment. The sponsor bears the responsibility to help create demand in the acquisition workforce, as that is beyond the scope of the project. The sponsor is considering adding the completion of the content of this program to the credentials necessary to advance in the acquisition workforce. This also involves risk, since

there are many stakeholders involved in the management of the qualifications of the acquisition workforce, and the M&S CO is but one of them. The risk to the academic partners has been mitigated by paying them the full cost to develop their materials, but there is still risk to DoD; if we "build it, but they do not come."

Integration is emerging as a challenge. The curricula must be vertically and horizontally integrated. We acknowledge that there is risk when there are so many different delivering institutions involved. Our mitigation strategy is to provide detailed templates and regular feedback. This still promises to be a challenge.

CONCLUSION

This project is immensely challenging. We believe that the only way it can be successfully completed is to apply basic systems engineering principles to the design and execution of the curricular design. We are taking a top-down approach, addressing the curricular system as a whole. We are also taking a life-cycle approach. We have diligently worked to establish the educational skill requirements, and we are developing the delivery requirements as of this writing. We have structured feedback loops into the program. Last, we have built a team that is inter-disciplinary, inter-departmental, and inter-scholastic.

The requirements that we have identified are an important step towards the improvement of the acquisition workforce, the better implementation of M&S in acquisition activities, and the continuing transformation of the way the acquisition enterprise does business.

This effort has been noted as a model for other Defense educational initiatives. In particular, the re-engineering of the Navy Systems Engineering training and education strategy is being based on a template derived from this approach.

ACKNOWLEDGEMENTS

We acknowledge the significant contributions of CAPT Mike Lilienthal, USN, who conceived the vision for this effort and who continues to hold a significant role in shaping and executing that vision. We also acknowledge our NPS partners, Drs. John Dillard, Young Shin and Rudy Darken, who have been instrumental in the execution of our plan. In particular, they led the development of the program manager, operational and logistics, test and evaluation, and engineering ESRs. Mr. Marshall Engelbeck assisted in the development of the acquisition-related ESRs.

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Systems Engineering Plan Preparation Guide Update

Chet Bracuto
OSD Systems and Software Engineering/Enterprise Development
24 October 2007
NDIA SE Conference

An Updated Systems Engineering Plan Preparation Guide (Version 2.0) Has Been Released on the New SSE Website

http://www.acq.osd.mil/sse/index.html

Preface + 3 Distinct Sections-94 Pages

SEP Prep Guide
History

- Version 1.02 released in February 2006 (31 pages)
  - Describe application of SE in the various life cycle phases
  - Provide information to specific questions for each of the CR/TD, SDD/Production, and Sustainment phases

SEP Prep Guide

Reasons for Update

- SEP quality was inconsistent
- ‘Lessons Learned’ from PSRs
- Feedback from SEP Reviews

SEP Prep Guide

Update Process

- ED released a draft SEP Prep Guide on 27 April for review by the SE Forum members and other SE personnel.
  - *600 comments received and adjudicated*
- ED released a second draft on 25 July
  - *close to 100 additional comments received and adjudicated*
- Released Version 2.0 of the SEP Prep Guide on 18 October 07 (Preface + 3 distinct sections-94 pages)

SEP Prep Guide

Goals

- Provide clear and unambiguous guidance on SEP preparation with lessons learned
- Assist the SEP Preparation Team by tailoring sections for Acquisition Milestones A, B and C
- Prompt the SEP Preparation Team to consider key planning factors in each focus area

It's About Technical Planning…Not the Document

SEP Prep Guide

Update Details

- New guide includes sections by program phase:
  - *Milestone A/Technology Development*
  - *Milestone B/System Development & Demonstration*
  - *Milestone C/ Production & Deployment and Operations & Support*

- Each section is based on technical planning focus areas for that phase
  - *Program Requirements*
  - *Technical Staffing*
  - *Technical Baseline Management*
  - *Technical Review Planning*
  - *Integration with Overall Management of the Program*

SEP Prep Guide

Update Details

- Program Requirements
  - Describe:
    - *Desired capabilities and traceability to requirements*
    - *Statutory and regulatory*
    - *Specified and derived*
    - *Certification*
    - *Design considerations*

SEP Prep Guide

Update Details

- Technical Staffing
  - Describe:
    - *Lead Systems Engineer/Functional roles*
    - *IPT Organization/Structure*
    - *IPT Staffing*
    - *IPT Coordination*
    - *Integration with the Contractor and External Organizations*

SEP Prep Guide

Update Details

- Technical Baseline Management
  - Describe:
    - *Who is responsible for technical baseline management*
    - *Approach to defining, approving and maintaining the baseline*
    - *Allocation and verification of program requirements*
    - *Alignment between the specification tree and the WBS*
    - *Assessment of technical maturity*

SEP Prep Guide
Update Details

- Technical Review Planning
  - Describe:
    - *Event-driven technical reviews*
    - *Technical review management*
    - *Chairing of technical reviews*
    - *Stakeholder participation in technical reviews*
    - *Peer participation in technical reviews*

SEP Prep Guide

Update Details

- Integration with Overall Management of the Program
  - Describe:
    - *Linkage to other program management plans (Acquisition Strategy, IMP, IMS, EVM, Risk, etc)*
    - *PM's approach to technical reviews*
    - *Risk management approach*
    - *Integration of T&E*
    - *Integration with Sustainment*
    - *Integration of SE considerations into the contract*

The Way Ahead
Communicate/Implement

- Communicate the new SEP Prep guidance to Government and Industry

- Implement:
  - Initial SEPs submitted for MDA approval shall be IAW SEP Prep Guide Version 2.0 on 1 Jan 08
  - Updated SEPs submitted for MDA approval shall be IAW SEP Prep Guide Version 2.0 on 1 June 08

The Way Ahead

Update the DAG

Incorporate new SE Policy in DoD 5000.2

- Enclosure 12. Includes new policy on CM, DM, and ESOH and previously approved SE and related policies.

- Enclosure 3. Table E3.T2. SEP is mandated at milestones A, B, and C.

- § 3.5.5. SE "shall be considered" during CR and TD.

- § 3.7.7. "System Design [phase of SDD] shall include the establishment of the functional, allocated, and product baselines for all configuration items."

- § 3.7.8. Proceeding beyond the CDR. "The system-level CDR provides an opportunity for mid-phase assessment of design maturity as evidenced by measures such as successful completion of subsystem CDR; the percentage of hardware and software product build-to specifications and drawings completed and under configuration control."

- § 3.7.9. System Demonstration. "The program shall enter System Demonstration when the program has successfully completed the system-level CDR and established an initial product baseline."

- § 3.10.5. Program Support Reviews (PSRs) mandated for all MDAPs and ". . . shall be conducted prior to each milestone event, before approval of the SDD acquisition strategy, and at other times as directed by the USD(AT&L)."

The Way Ahead

SE Plan Unification

Working Towards a Unified Systems Engineering Plan

NDIA 10th Annual
Systems Engineering Conference

October 24, 2007

Col. Richard Hoeferkamp
DoD OUSD A&T (SSE)

Robert (Bob) Scheurer P.E., P.M.P.
Boeing Integrated Defense Systems

Purpose

Present findings of SE Working Group discussion between ODUSD (A&T/SSE) and Boeing on Acquirer - Supplier technical planning

Background

Mission:

"Define the environment within which SEP/SEMP unification can be enabled, agreed upon, and executed. These documents, which may be initially separate, will be unified into a single document by the time of IBR but still link to related, subordinate documents that are likely specific to the Acquirer and Supplier."

Progression of Discussions

SEP – SEMP alignment

- Similarities and differences between Acquirer & Supplier SE Plans
- Intent of both
- Gaps and misalignments between the two
- Influences of existing policy & guidance, incl. DID 81024 Systems Engineering Management Plan

Migration from alignment of “SEP / SEMP” to unification

- Pros and cons of Acquirer / Supplier unification: from Pre-RFP to Post-contract award
- Unified SE planning phasing

Methodology towards a unified approach

Acquirer: DoD
Supplier: Prime Contractor and its Suppliers

DoD SEP Prep Guide & Sample Supplier SEMP

SEP Prep. Guide 2nd Edition V1.0

1.0 Introduction

2.0 Program Reqmts

3.0 Technical Staffing & Org. Planning

4.0 Technical Baseline Management

5.0 Technical Review Planning

6.0 Integration with Overall Management of the Program

Supplier SEMP

1.0 Introduction

2.0 Applicable & Reference Documents

3.0 Program Overview

4.0 SE Organization Integration & Tech Authority

5.0 SE Technical Processes

6.0 SE Mgt. Processes

7.0 Integ. With Prog. Mgt. Efforts

8.0 Transitioning Critical Technologies

9.0 Integ. Environment for Sys. Engineering

10.0 Additional SE Activities

11.0 Supporting Plans

12.0 Notes

No Direct Correlation To SEP

Respective Guides Address Many Common Topics

Why Not A Single SE Plan?

Pros :

- Common vision
- Acquirer/Suppliers with stronger team emphasis
- Shared responsibilities
- Clear understanding of programmatic & technical planning
  - Drives alignment of program support documents (IMP/IMS, SOW, WBS, PEP, TEP, etc.)
- Potential downstream cost avoidance & schedule savings

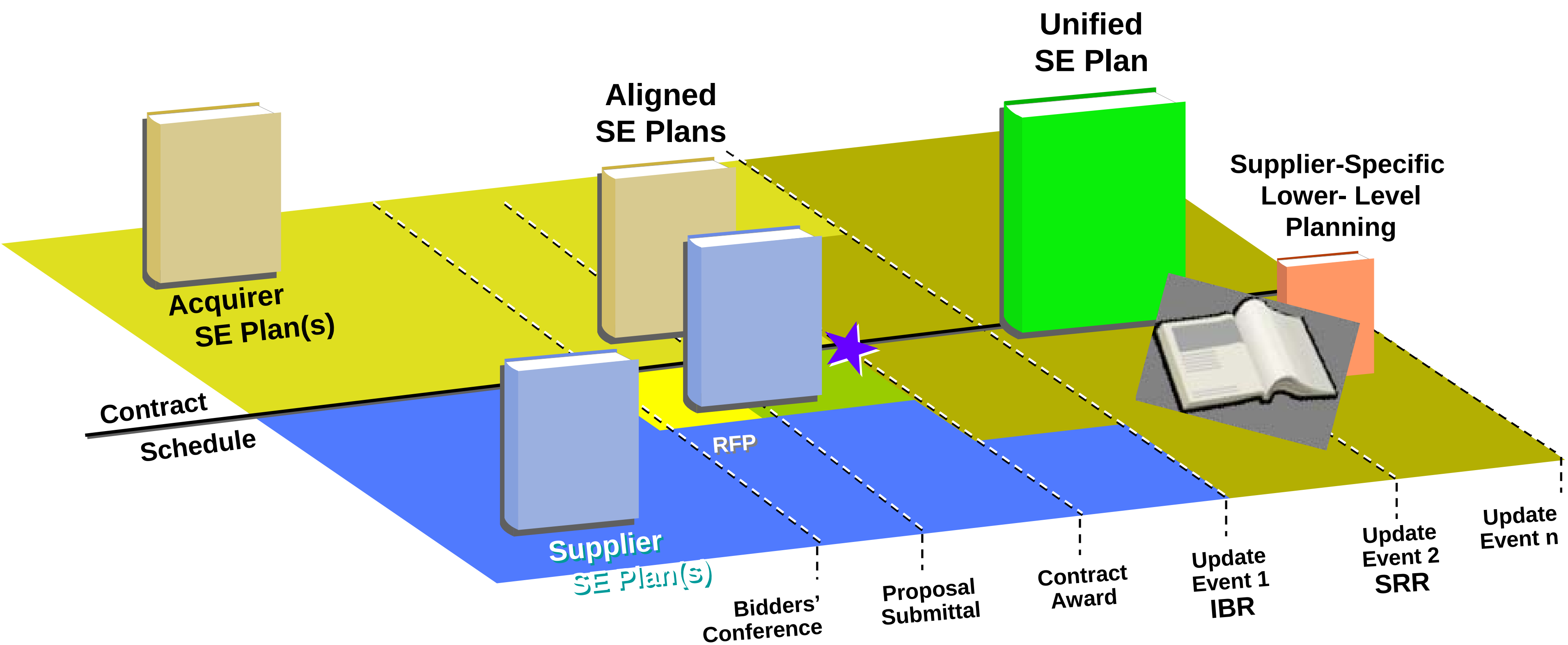
Cons:

- Cultural changes (i.e. not accustomed to a unified SE Plan)
- Additional up front planning time
- The challenge of achieving greater communication between Acquirer / Supplier
- Potential contractual ramifications when updating plan
- Lack of detailed implementation / experience on both sides
- Potential increase in contract proposal costs?

Vision: SE Plan Unification

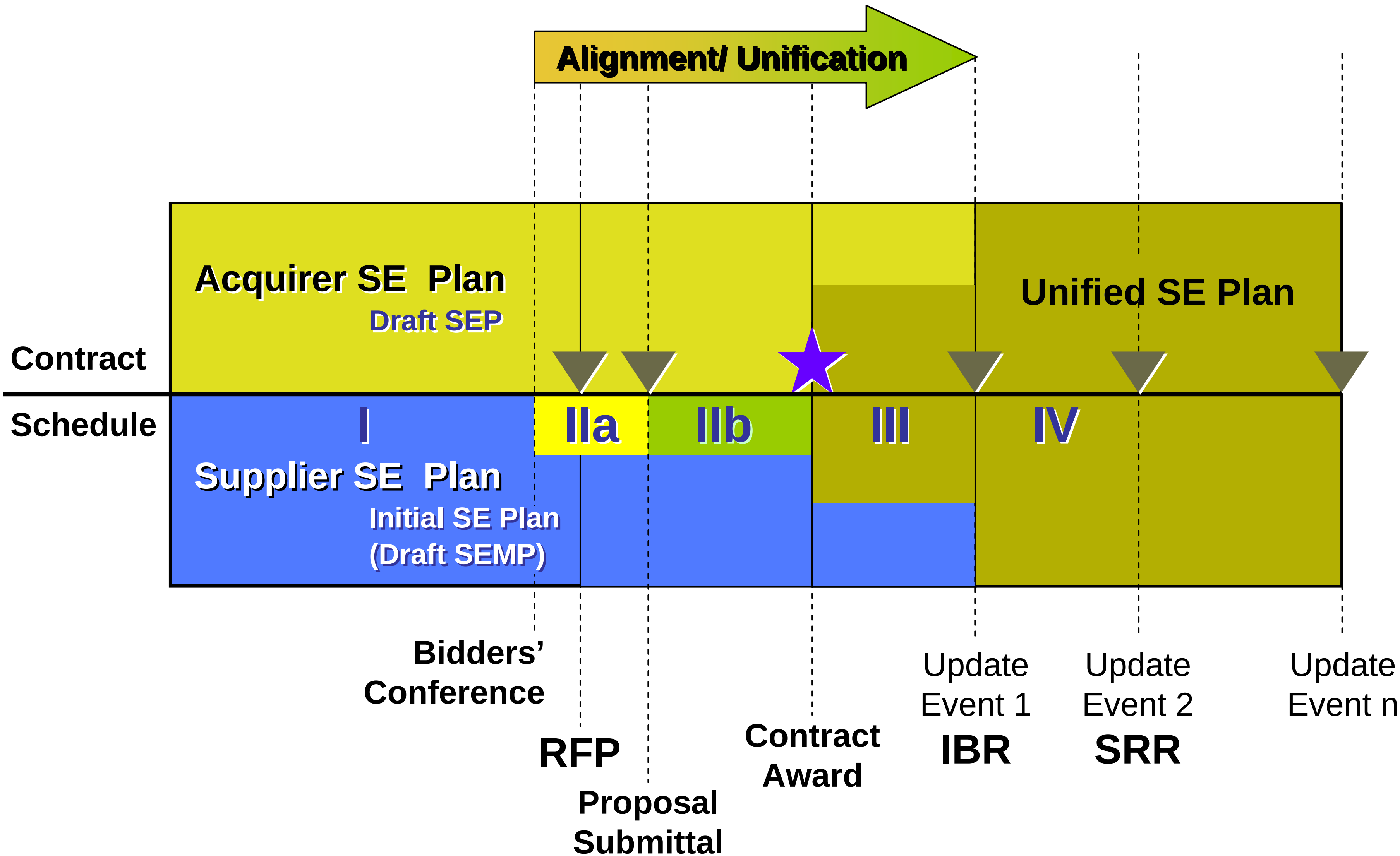
- <u>Acquirer/Supplier-developed technical plan</u> for SE implementation
- Acquirer/Supplier <u>shared roles and responsibilities</u> in SE effort
- Acquirer/Supplier conducted <u>event driven technical reviews</u>
- Acquirer/Supplier <u>teaming on linkage with other program plans</u>

Path to a Unified SE Plan



Unified SE Planning Phasing

Notional Draft for Typical SDD Program



Phase I

Leading Up to Bidders' Conference

Situation:

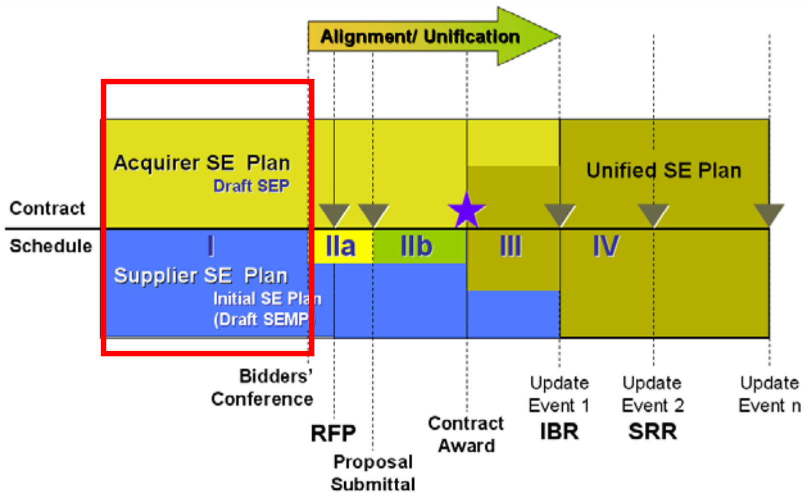
Acquirer requirements emerging for upcoming acquisition

Supplier technical solutions or solution components evolving (potentially independently developed)

Activities:

Acquirer developing draft SEP for Bidders' Conference (for prospective Supplier(s) feedback)

Prospective Supplier(s) developing draft SEMP for emerging proposed technical solutions



Phase IIa

Post-Bidder's Conference to Proposal Submittal

Situation:

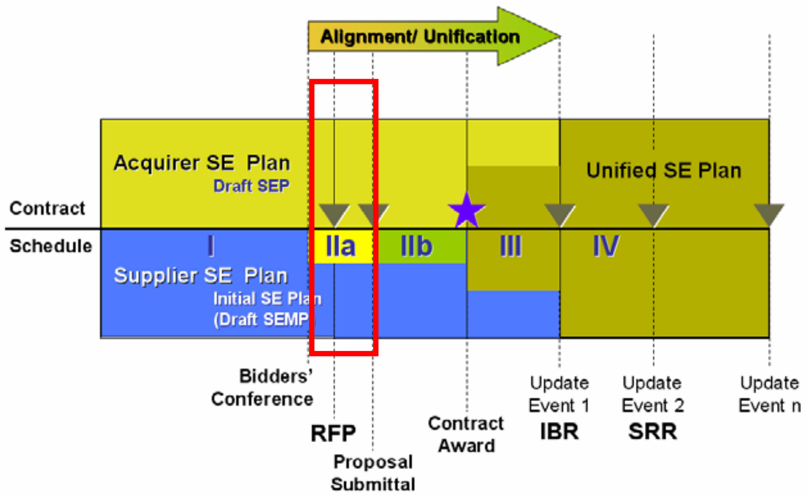
Suppliers have awareness of Acquirer's Draft SEP content

Activities:

Acquirer making updates to SEP based on Bidder's Conference feedback

Supplier making modifications to Draft SEMP and lower tier plans for alignment to SEP

Initial Supplier identification of integration issues, risks, and opportunities in the proposal



Phase IIb

Post-Proposal Submittal to Contract Award

Situation:

Acquirer will have received SEMP(s) from the Supplier(s)

A generally-quiet period from the standpoint of Acquirer-Supplier planning interaction

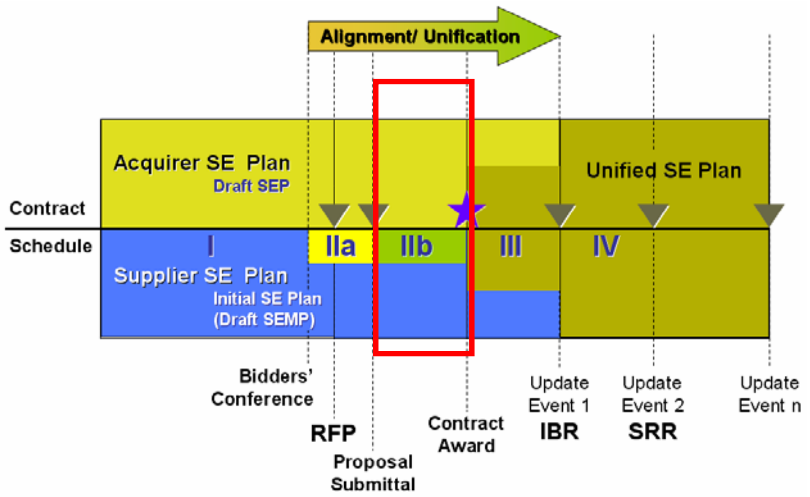
Activities:

Acquirer evaluating Suppliers' SEMP(s), associated plan artifacts (IMP/IMS), and quality of the Acquirer planning in the proposal.

Acquirer makes prospective modifications to SE Plan framework per selected Supplier SEMP

Supplier(s) performing implementation preparations in anticipation of ATP / Contract Award

Additional integration issues, risks, and opportunities identified



Phase III

Post-Contract Award to IBR

Situation:

Many opportunities for planning changes

Time for the most significant plan unification to occur, all under the constraints of the contract

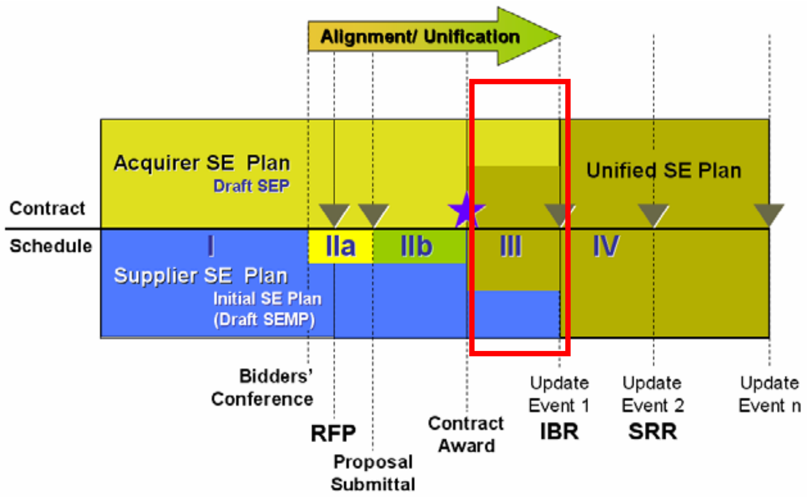
Activities:

Substantial discussions regarding the push toward a unified SE Plan.

Both Acquirer and Suppliers adjusting planning to better align with contractual commitments

Integration issues resolved and mitigation/ realization plans developed

More specific planning details emerging and established



Phase IV

Post-IBR

Situation:

Unified SEP

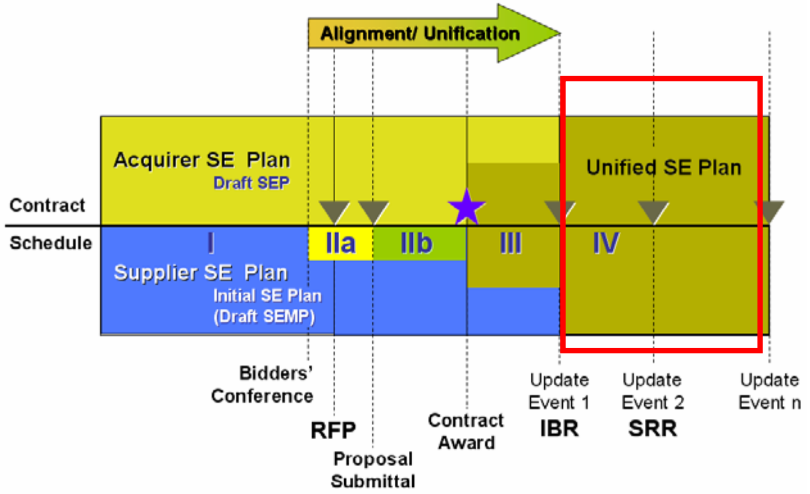
Activities:

Unified plan being implemented/executed, w/success dependent upon how well the contract was structured.

Results of program execution may vary (w/plan variation) depending on whether the program contract is “Cost Plus” or “Firm-Fixed Price”

Opportunities being identified for next

Unified SE Plan Update Event



Summary of Phasing

- Unification requires reference to OSD “SEP Prep Guide,” “Integrating SE with DoD Acquisition Contracts Guide,” and relevant industry SEMP Guide

- RFPs will include Acquirer (Govt.) SE Plan

- Unified SE Plan: A single unified technical planning document detailed down to a specified level that integrates (after contract award) the SEP (Govt SE Plan) in the RFP with the SEMP (Industry SE Plan) in their original proposal

Threats to Plan Unification

- Languaging/Definitions
- Organization and Cultures
- Proprietary Limitations
- Contractual Constraints
- Working Relationships of Participants

Way Ahead

Share findings with Government & Industry Forums -- solicit feedback

- SE Forum
- NDIA SE Conference, Oct 07
- Other

Coordinate unified SE plan implementation details with contracting

Propose DoD policy to implement unified SE Plan

Review various guides for revisions as appropriate pending policy decision

Update DID 81024 - Systems Engineering Management Plan

Questions?

- What Show Stoppers to this Concept?
- What Would be the Update Frequency, Criteria, and Approval Authority for this Concept?
- How Might This Process be Prototyped?
- What Front-End Guidance Would You Give to the Acquirer (e.g., DoD) for Deploying this Concept?

Backup/Reference Material

Working Group Approach

Coordination between SE planning representatives of Govt. & Boeing

Establish vision and scope (topics) of discussion/ engagement

Share experiences, best practices, & lessons learned

Identify implementation/ improvement opportunities

Jointly share findings & recommendations

SE Planning Update Event Types

New Initiative (Start SEMP)

Authorization to Proceed (ATP)

Program Milestone Reviews

Periodic/Scheduled Updates

Coordinated with Other Significant Document Updates

- PEP
- Subordinate Documents (e.g., TEP, RMP, etc.)
- Supplier Plans

Leading/Lagging Indicators Signaling the Need

- Tests (Failures)
- Significant Changes in Program Events/Outcomes
- Audit Results
- Comments from
  - Customers
  - End Users
  - Program Personnel

Current Findings / Considerations

Product of SE process is technical baselines and reviews

Emphasis should be on event-driven reviews; e.g., in the SEP or SEMP, how do you know when you are ready for CDR?

Describing your program processes <u>is not equal to</u> drafting your program SEMP or defining your plan

An objective of DoD is to eliminate “Canned SEPs” and “SEPs for Hire”.

A multi-faceted approach is being used by the DoD for implementing SE plans (SEPs) on programs and hopefully changing culture:

- Issuing the SEP Preparation Guide
- Conducting Awareness Training
- Performing Hands-On Follow-Up Activities

Program managers need to be more involved with systems engineering

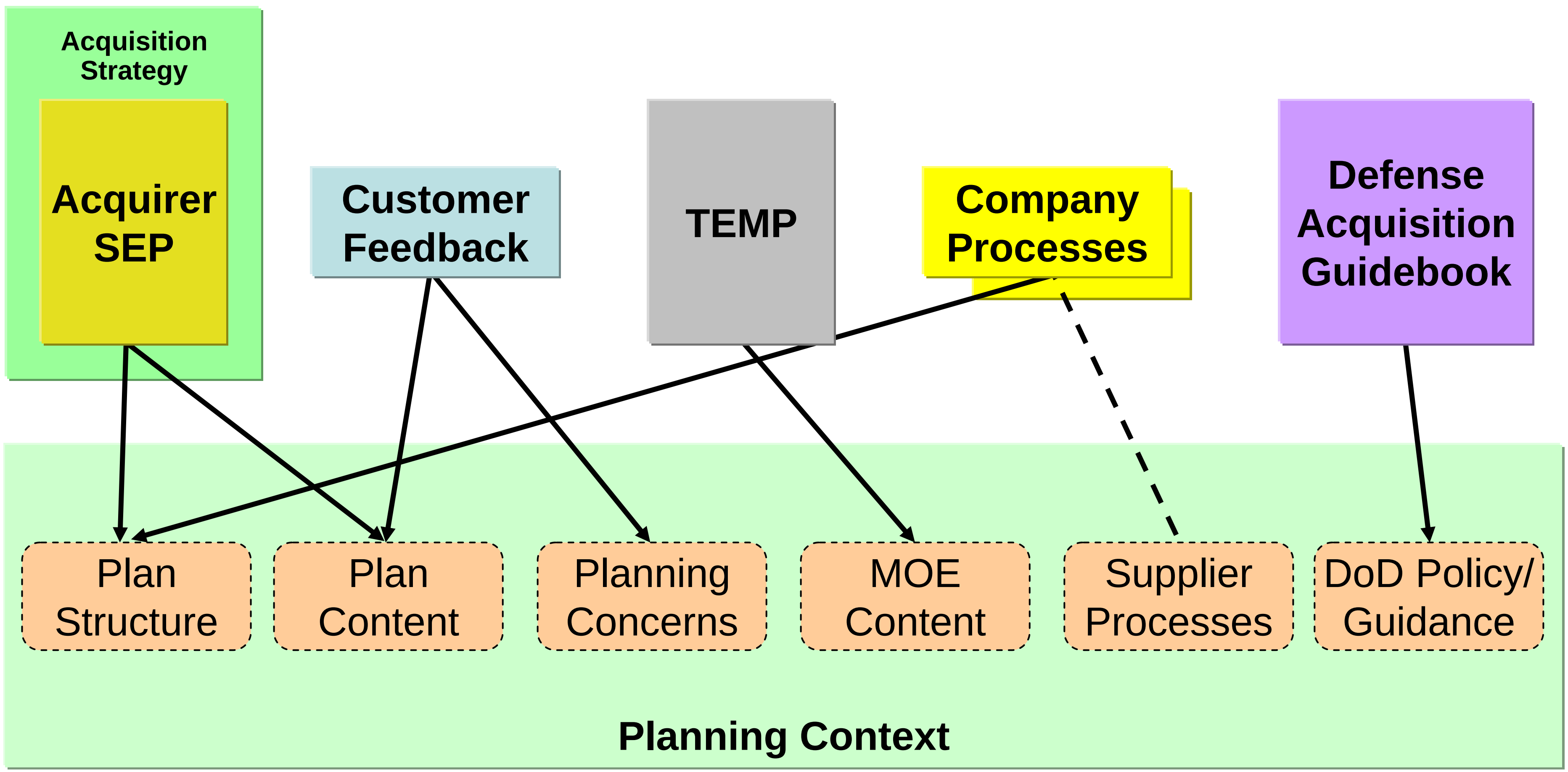
Recommendations by systems engineering must be taken more seriously.

SE Planning Environment

- Multiple Participant Bodies
- Multiple Teams
- Multiple Locales
- Multiple Levels of Interest
- Multiple Time Spans

Aligning & Unifying SE Plans

Step 1: *Identify* Plan Components



Aligning & Unifying SE Plans

Step 2: *Link* Plan Components

Acquirer SEP	**Supplier SEMP**
Program Requirements	System Capabilities
Technical Staffing and Org. Planning	Organization
Technical Maturation and Baseline Mgt.	SE Processes (Technical)
Technical Review and Audit Planning	SE Processes (Management)
Integration w/ Over-All Mgt. of Program	Integration of Technical Effort
	Additional SE Activities
	Supporting Plans

Defining Software Component Specifications: An Open Approach

Kenneth Klein
Computer Sciences Corporation

NDIA Systems Engineering Conference
October 22-26, 2007

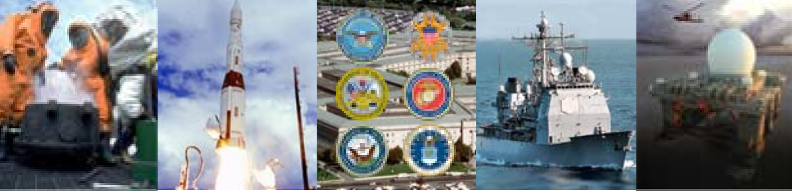
CSC
EXPERIENCE. RESULTS.

A Couple Definitions

- Open
  - Based on widely excepted and supported standards
  - Defines key interfaces using these standards
  - Not proprietary

- Software Component
  - A modular part of a software design that hides its implementation behind a set of external interfaces.
  - Within a system, components satisfying the same interfaces may be substituted freely.

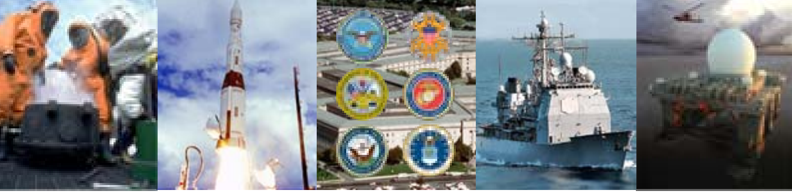
- That’s what the terms mean in the context of these slides….



The Problem

- Given an “as-built” component-based Department of Defense (DoD) software system
  - Code written in Java
  - Interface-based component services
- Needed an approach to documenting each component as a as a set of well-defined interfaces
  - Required to meet DoD “openness” standards
  - Critical for making components extendible and reusable

The problem has a problem…

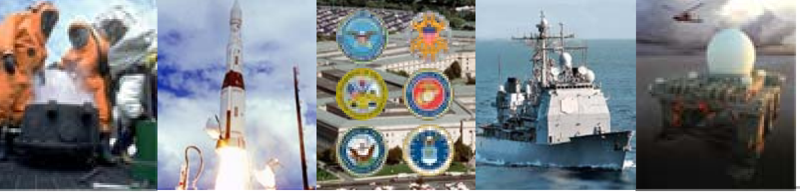


Well-Defined is not Well-Defined

- A lot of literature available on defining:
  - Information exchange standards, e.g., CORBA, JMS, DDS
  - Specific implementations of these standards
  - Component frameworks, e.g., SOA, EJB
  - Quality of Service requirements
- Not so much out there on defining a service’s functional behavior

The Solution

- Define the component and its services using:
  - Lightweight UML domain modeling
  - Design by Contract (DbC) principles
- Tools used
  - A UML modeling tool that can generate HTML output
  - Doxygen
    - Open source C++/Java documentation generation tool
      - Similar to Javadoc
        - » Recognizes Javadoc comment delimiters
    - Reads source code, generates HTML
    - www.doxygen.org
  - A web browser



Air,
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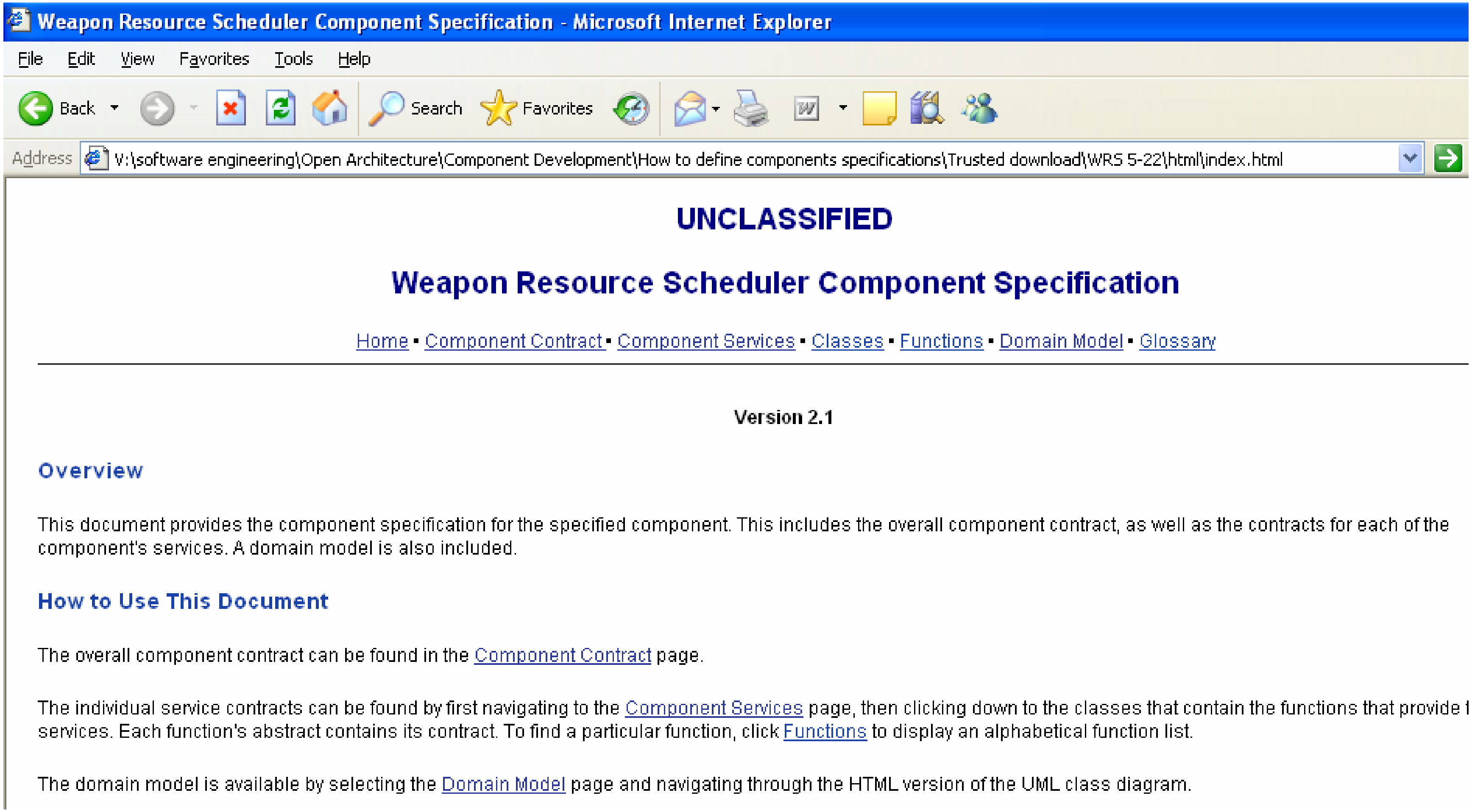
Navigating the Spec



Weapon Resource Scheduler Component Specification - Microsoft Internet Explorer

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UNCLASSIFIED

Weapon Resource Scheduler Component Specification

Home ▪ Component Contract ▪ Component Services ▪ Classes ▪ Functions ▪ Domain Model ▪ Glossary

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Version 2.1

Overview

This document provides the component specification for the specified component. This includes the overall component contract, as well as the contracts for each of the component's services. A domain model is also included.

How to Use This Document

The overall component contract can be found in the Component Contract page.

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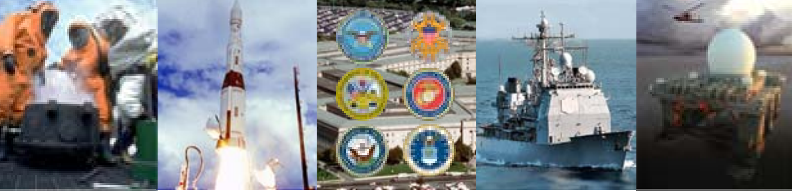
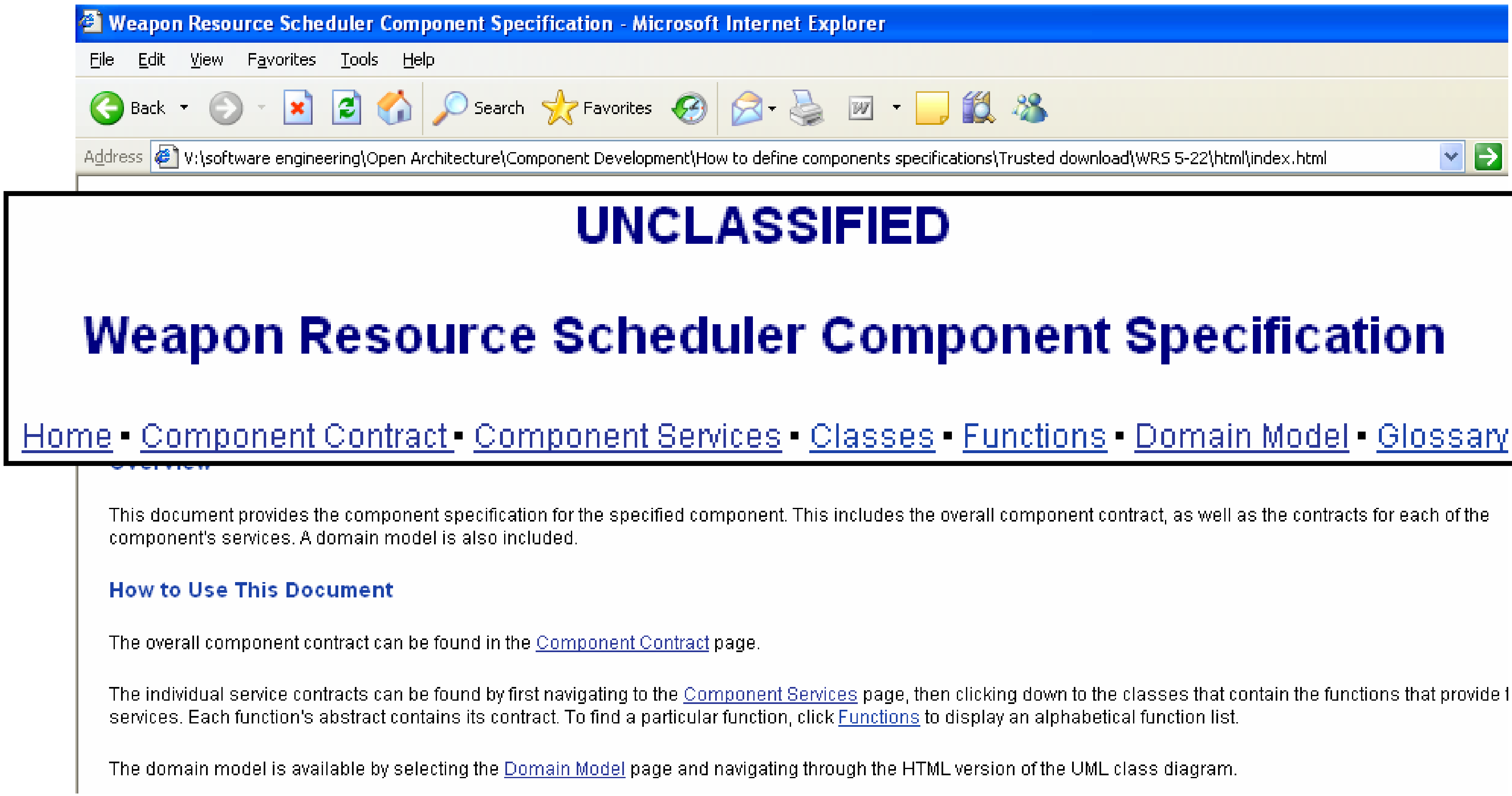
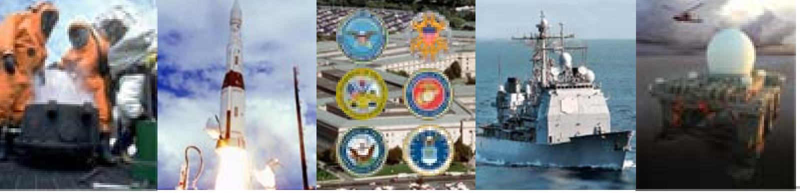


Navigating the Spec





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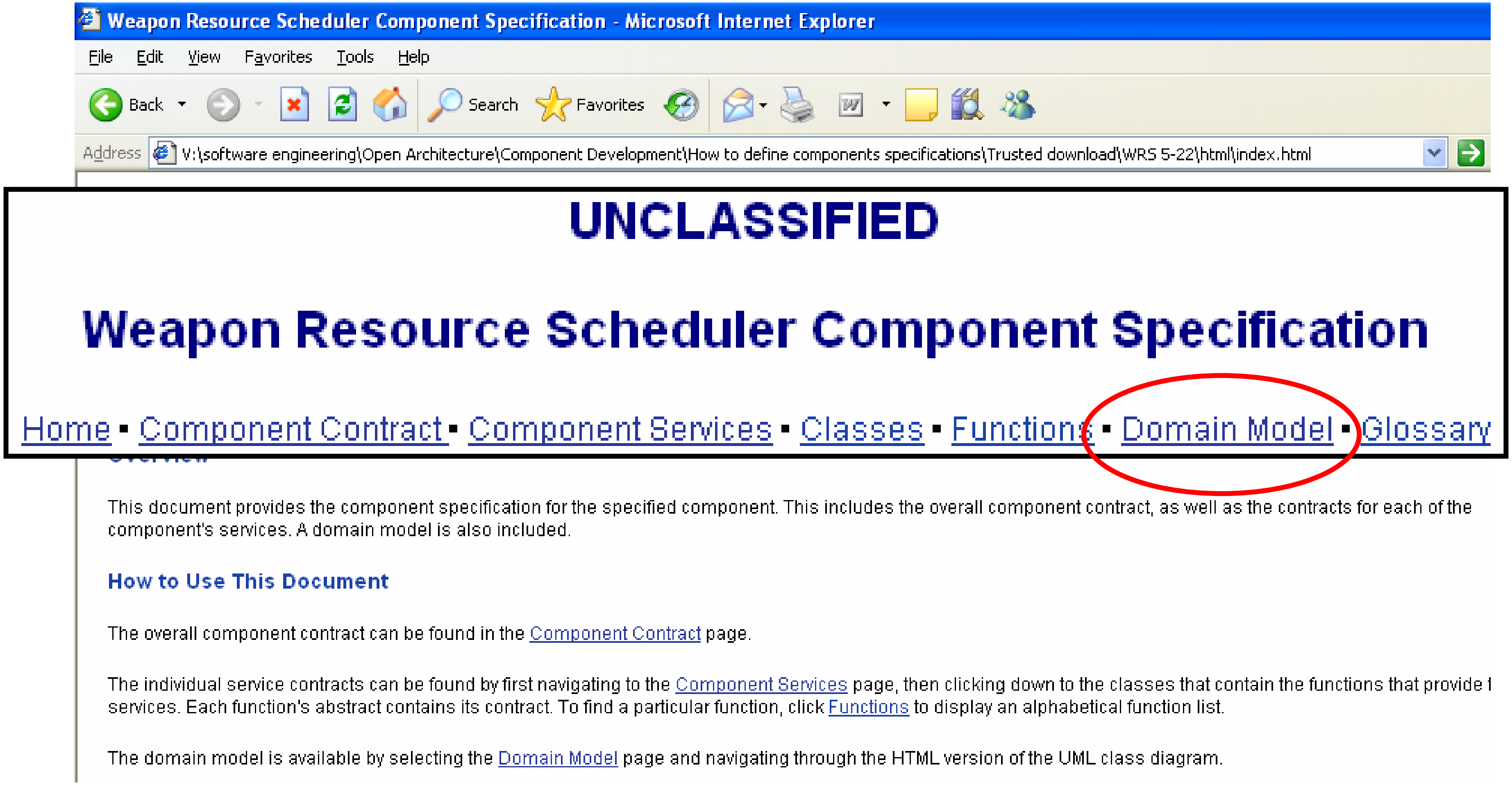
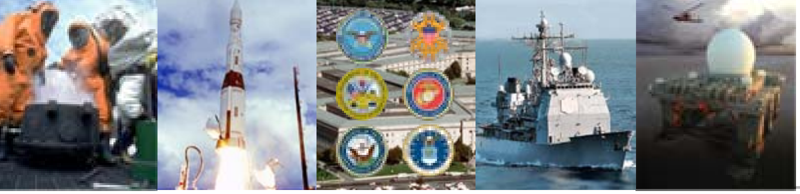
Domain Model: The Context Diagram

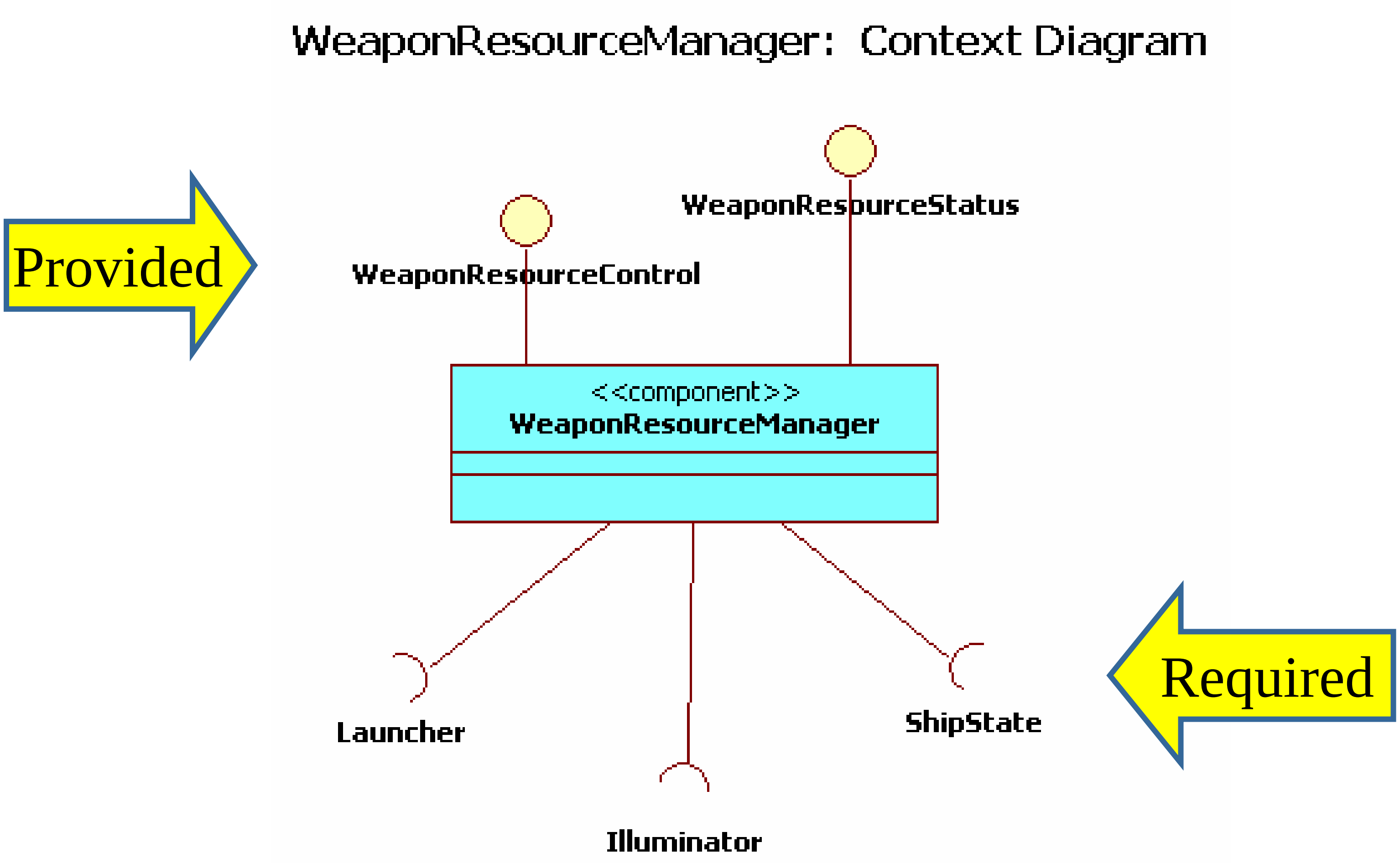




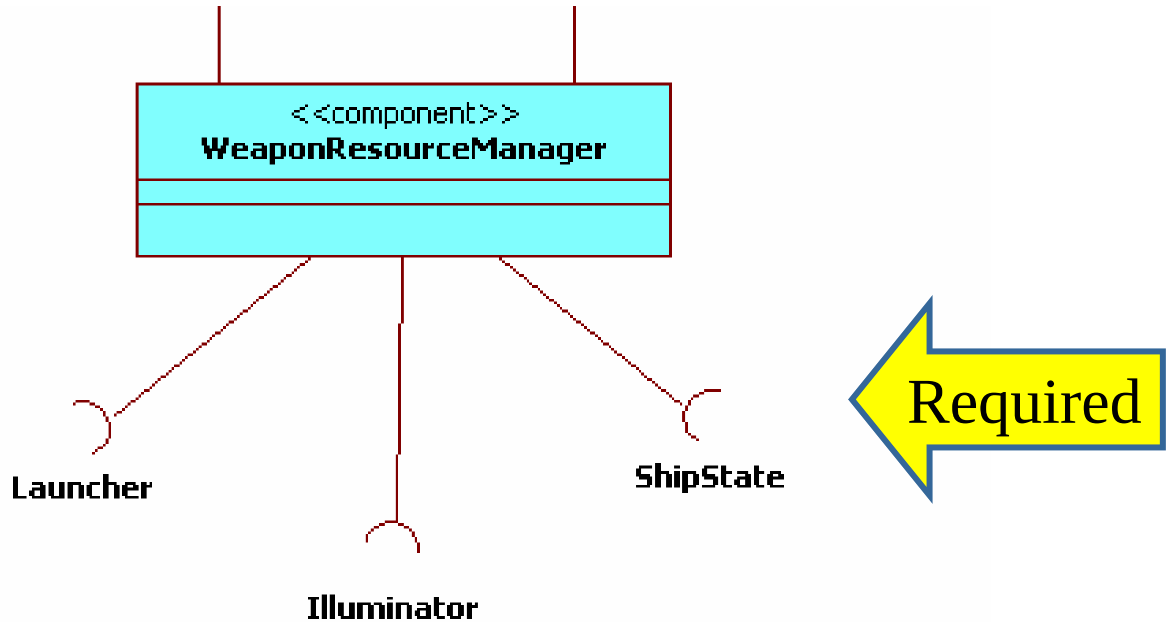
Context Diagram

- Shows component’s *provided* and *required* interfaces
  - Provided interface declares services that this component offers to external components
  - Required interface declares services that this component requires from external components
- Describes required interfaces in context of this component
  - Each component may describe the same required interface differently based on the component’s needs
  - E.g., given an Illuminator interface, one client may *require it to check Illuminator equipment status*; another client may *require it to Illuminate a target*

Context Diagram Example



Context Diagram Example (cont.)



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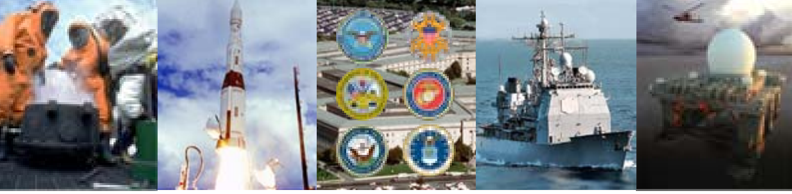
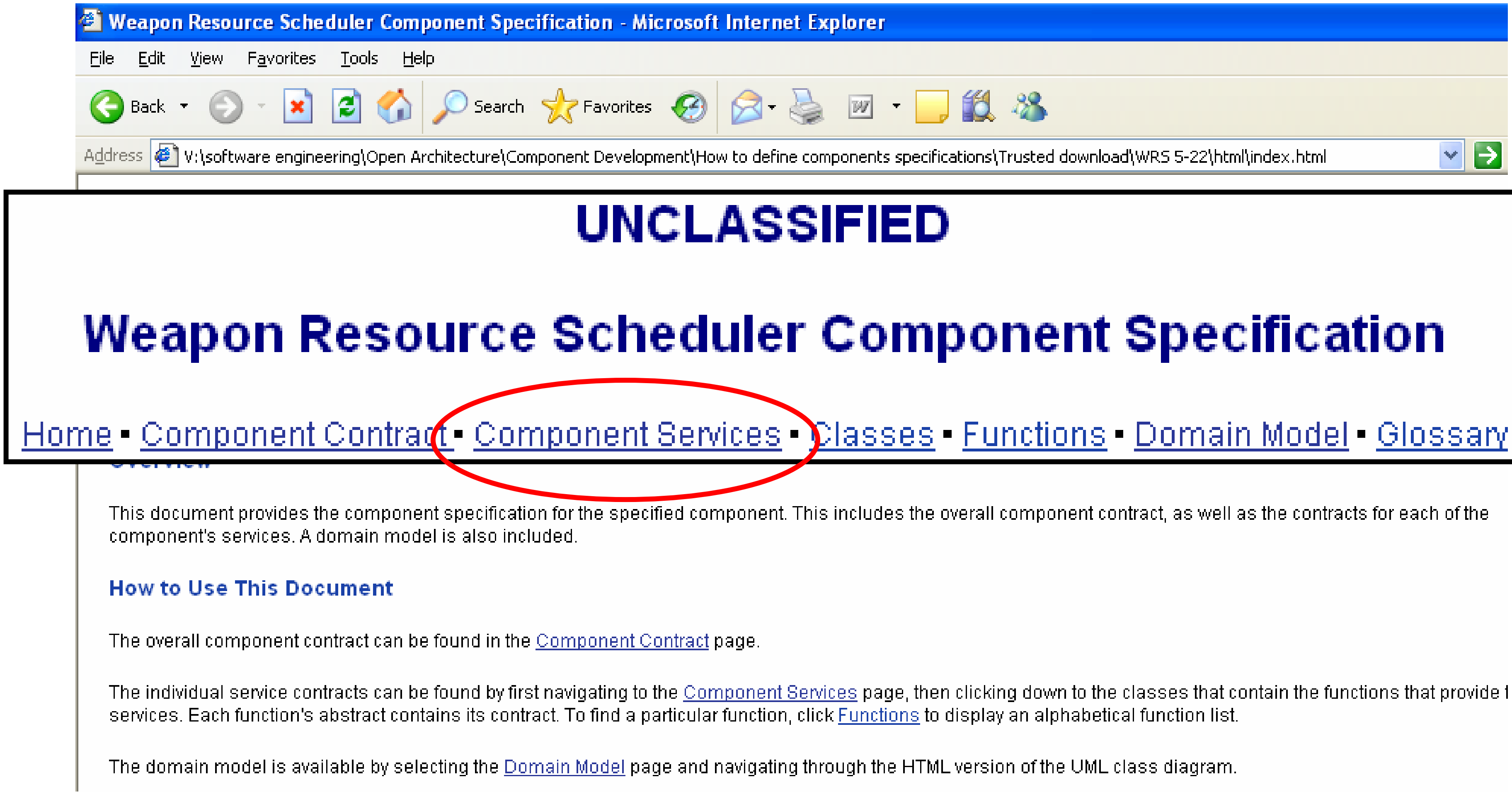
Documentation
The Illuminator interface is used to request the status of illuminators. It is also notified of illuminator faults.

Parent Package	ContextDiagram	**Abstract**	No



Component Services Example



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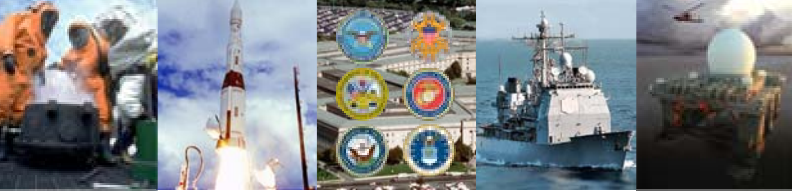
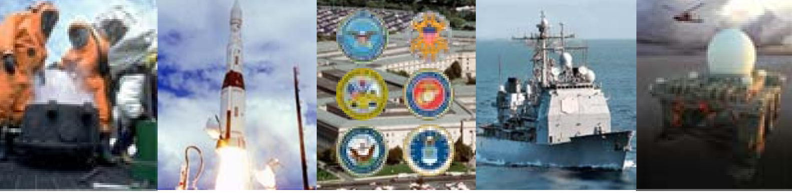


Component Services

- What is expected of the client?
- What does the service do?
- State all this with as few implementation details as possible
  - Most implementation choices should not impact the specification
  - More likely specification will remain unclassified
- **Design by Contract provides a solution**

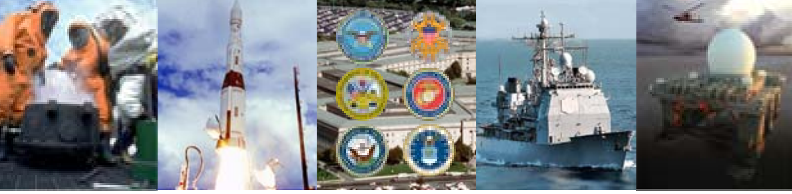


What is Design by Contract (DbC)?

- Defines the *contract* between the *interface* and its *clients*
- Preconditions
  - States that must be true when service is invoked
- Postconditions
  - If service is invoked when preconditions are true, postconditions describe guaranteed outcome
    - e.g., state changes, messages sent
- Invariants
  - Attribute constraints that must always be true:
    - After component instantiation
    - Before/after each service invocation
    - e.g., An Engagement must have exactly one Target
- Exceptions
  - Describes what happens when preconditions or invariants are violated or postconditions cannot be met
  - Behavior can be “undefined”

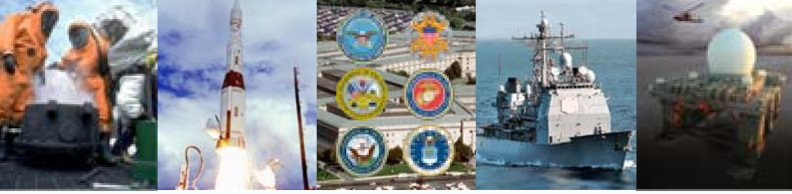
Why DbC?

- Well documented, mature paradigm
  – Term coined by Bertrand Meyer in 1997
  – Since then, large volume of literature written on the topic
    - See resource list
- Decoupled from implementation details
  – Guidelines for “just enough” information
  – Implementation can change without impacting contract
- Encourages discussions that may otherwise never occur
  – Provides common vocabulary for complex concepts
  – Exceptions often discovered when writing contracts



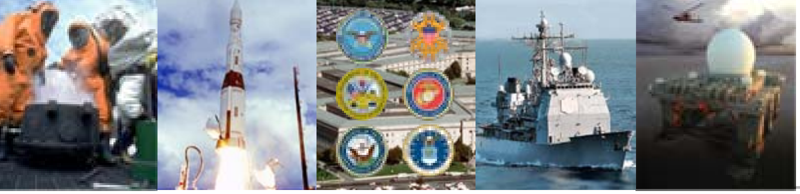
Why DbC? (cont.)

- Facilitates Liskov Substitutability Principle (LSP)
  - Service implementations/extensions *must not add preconditions or remove postconditions*
- Supports:
  - Maintainability/Extendibility/Reusability



DbC Note: Preconditions and Callbacks

- Callback services should not change the state that triggered the callback
  - Remaining observers will receive incorrect notifications
    - Subject component has a list of color observers
    - Subject reports “I just turned red”
    - One of the observers changes subject to blue
    - The remaining observers will incorrectly be notified that subject is red
- Mitigation
  - Subject component keeps track of whether a callback is in progress
  - Any offered service that could change an observed state *has a precondition* that notifications are *not* in progress
    - Above observer’s attempt to make subject blue would be rejected

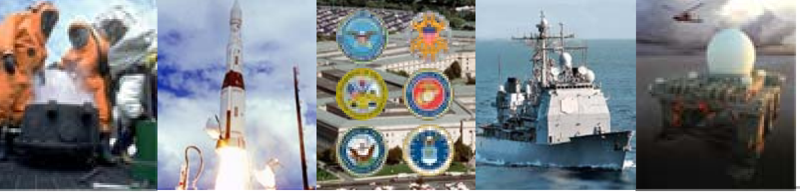


DbC Note: Maintaining the Invariants

- Exceptional service termination must restore component invariants
  - Otherwise, component is not stable, so its services' behavior is undefined
  - May be criteria for invoking recovery path
- Concurrency should only be allowed for services that can guarantee that preemption can only occur while the component invariants are in place
  - Mitigated by many concurrency oriented architecture and design patterns
    - See *Pattern-Oriented Software Architecture Vol. 2: Patterns for Concurrent and Networked Objects*

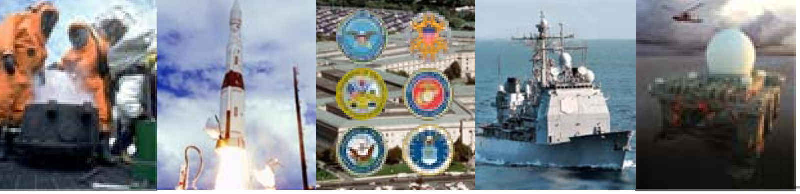
Component Service Contracts

- Method signature
  - Captured as-is from source code
- Preconditions/Postconditions/Exceptions
- Query or Command
  - Does the service change the parameters' or the component's state?
- Parameters
  - Constraints
    - E.g., valid ranges, precision, units
  - Is ownership transferred?
    - If "no," client must be notified of any state changes
  - Type Definitions
    - Imported as-is from source code
    - Linked via hypertext



Component Service Contracts (cont.)

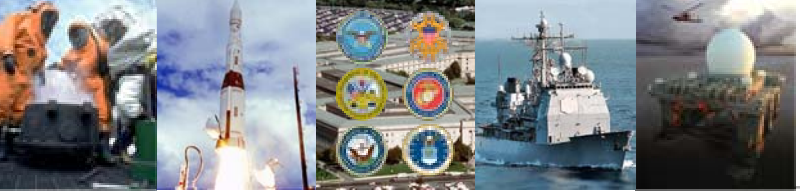
- Quality of Service
  - Performance, throughput, blocking, availability
- Is concurrency allowed?



Service Contracts as Comments in the Code

- From *The Mythical Man Month* (M3), pg. 169 [Fred Brooks, 1995] (first edition published in 1975)
  - We typically attempt to maintain a machine-readable form of a program and *an independent* set of human-readable documentation, consistent of prose and flow charts.
  - The results in fact confirm our teachings about *the folly of separate files*. Program documentation is notoriously poor, and *its maintenance is worse*.
  - **The solution, I think, is to merge the files, to incorporate the documentation in the source program.**

- This is what Doxygen does…



Component Services Example: Java Code

```
/**
 * DESCRIPTION:
 * <p>
 * This method will distribute the request to the WeaponResourceManager.
 * <p>
 * @param[in] request  The request being sent to the WeaponResourceManager.
 *       -# Valid ranges
 *                - Not null
 * @par Query or Command:
 *       Command
 * @pre
 *       -# None.
 * @post
 *       -# If the request is an Alpha Request, it was added to the
 *          Illuminator Schedule.

...
*/
public void setRequest( RequestIF request );
```

Component Services Example: Doxygen Output

void WeaponResourceManager::setRequest (RequestIF *request*)

DESCRIPTION:

This method will distribute the request to the **WeaponResourceManager**.

Parameters:

[in] *request* The request being sent to the **WeaponResourceManager**.

1. Valid ranges
   - Not null
2. Ownership transferred (Y/N)? Y

Extracted from code comment block

Query or Command:

Command

Precondition:

1. None.

Postcondition:

1. If the request is an Alpha Request, it was added to the Illuminator Schedule. This processing includes the use of the Illuminator interface to acquire equipment status.
2. If the request is a Beta Request, it was added to the Launcher Schedule. This processing includes the use of the Launcher interface to acquire equipment status.

Exceptions:

NullRequest The request is null. Behavior undefined.

Blocking (Y/N):

N

Component Contract Example

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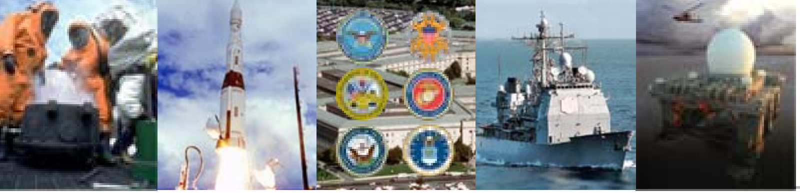
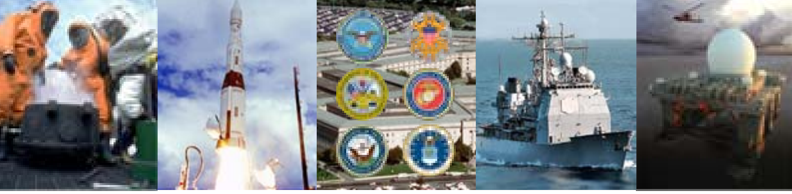


Component Contracts

- Preconditions/Postconditions
  – Before and after component startup, respectively
- Invariants
  – Applicable to component as a whole
    - Each is a pre & post condition for every service
- Exceptions
  – If pre/post conditions or invariants violated
- "Full load" memory requirements
- Proven hardware platform and OS support
- Communication standards and implementations
  – E.g., JMS/Websphere, DDS/NDDS 4.0, CORBA/ACE TAO
- Other Protocols/Standards
  – POSIX, SNMP, .NET, etc.



Component Contracts (cont.)

- Programming Languages
- Configuration file dependencies
- Availability requirements, e.g., MTBF

Component Contract Example

WeaponResourceManager Component Contract

Precondition:

The AlphaProperties configuration file must exist.

The initial state must be provided.

Postcondition:

The WeaponResourceManager was started and the initial state was set using the provided parameter.

The WeaponResourceManager applied the states found in the AlphaProperties file.

Communications were established with the Illuminator, Ship and Launcher components.

Invariant:

Communication must be maintained with the Illuminator, Ship and Launcher components.

Exceptions:

MissingPropertiesFile	The AlphaProperties file does not exist. Error is logged and program exits.
InvalidProperties	Properties in the AlphaProperties file were missing or invalid. The properties are set to their default values.
RequiredComponentsUnavailable	Unable to communicate with the Illuminator, Ship or Launcher. Behavior undefined.

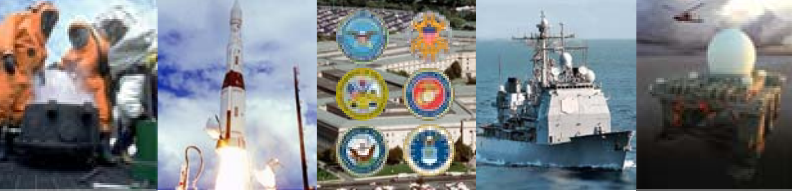
Standard Used for Invoking Services

JMS/Tibco 4.0.0

Language Dependencies

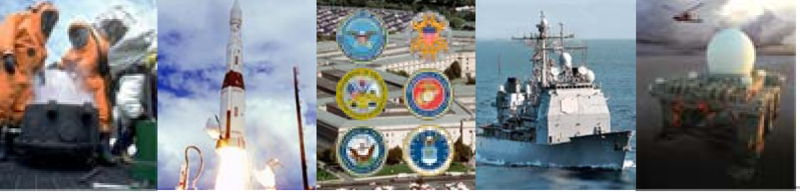
Java 5.0

More below…



Contract Ambiguity Problem

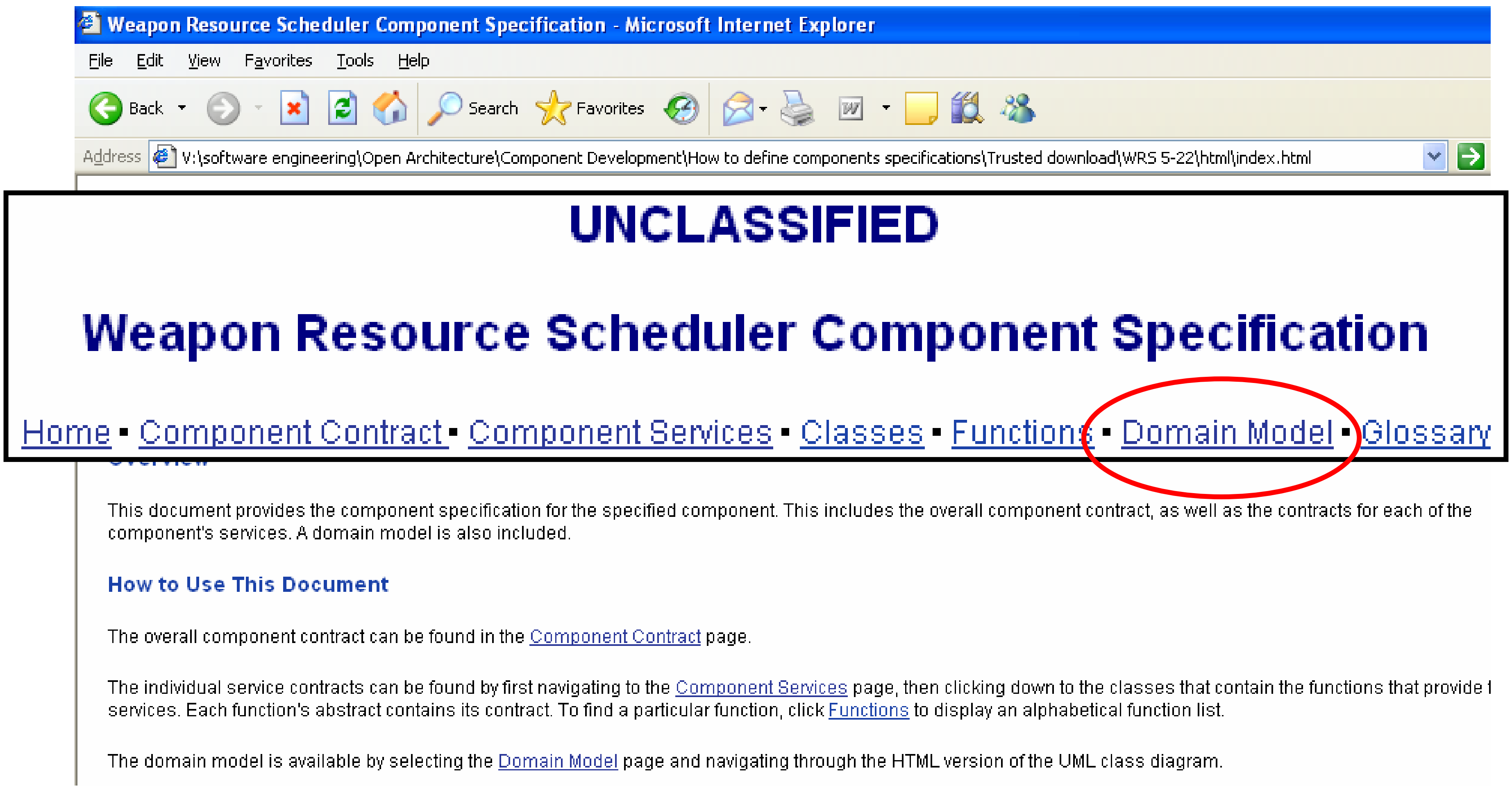
- From *M3* pp. 63-64
  - Human language is not naturally a precision instrument for [specification] definitions.
  - Formal definitions are precise. What they lack is comprehensibility.
  - **I think we will see future specifications to consist of both a formal definition and a prose definition.**
- This is what the Domain Model does…



Contract Ambiguity Solution: The Domain Model

- Provides formality of UML
  - Each domain class is clearly defined in the model
- Contracts reference domain classes in plain English
- What is a domain class?
  - Real-situation *notional* class in a domain, e.g., Launcher Schedule, Target, etc.
  - They are not actual software implementation classes
- Why not implementation classes?
  - *M3* says (pg. 175): “If one uses only a *highest-level structure graph*, it might safely be kept as a separate document, for *it is not subject to frequent change*.”
  - Notional domain classes are stable, because they are decoupled from implementation details

Domain Model Example



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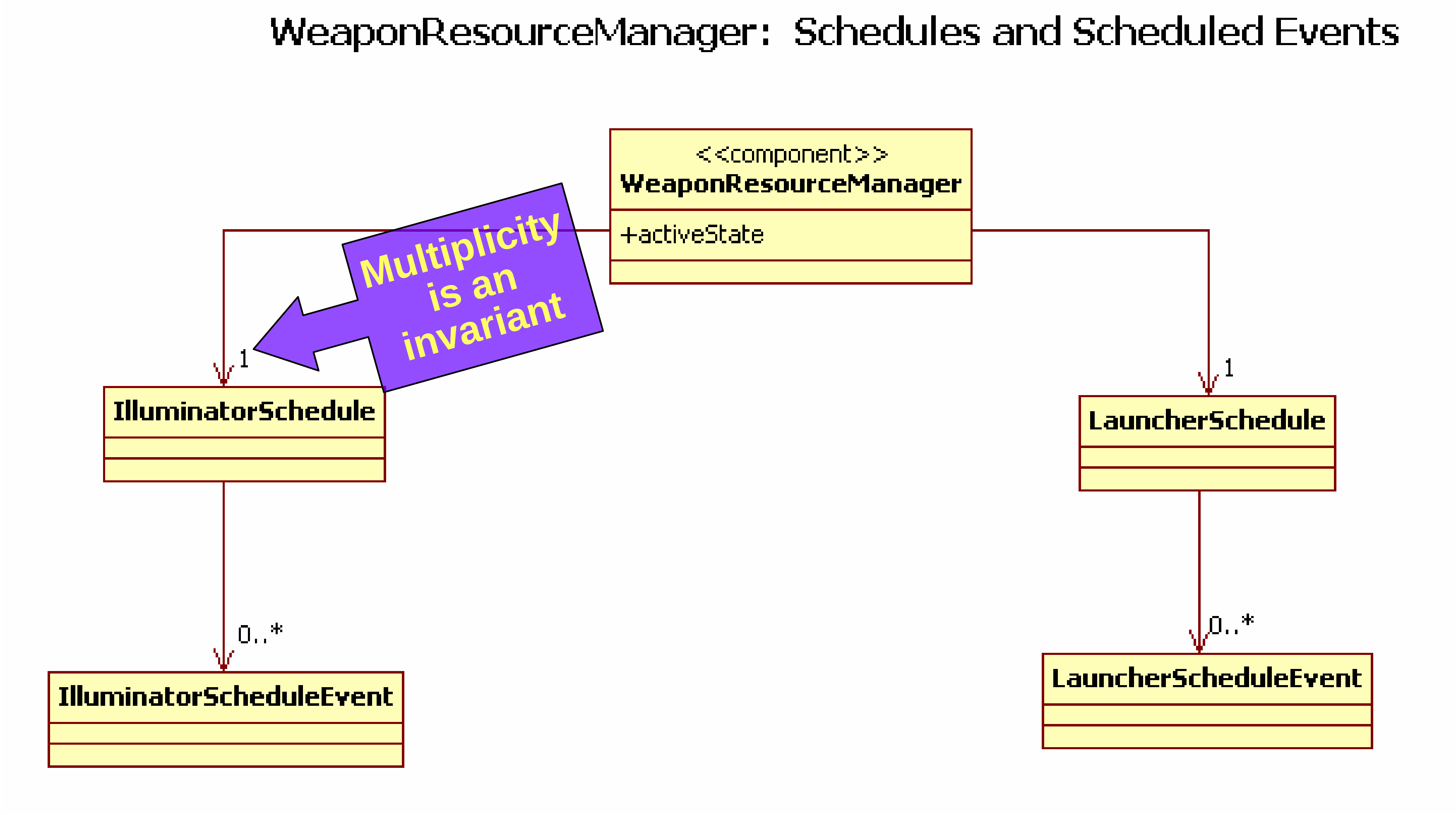

How Domain Model Relates to Contracts

Contract

Postcondition:

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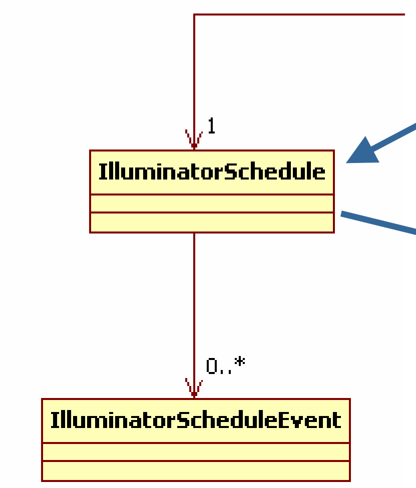
2. If the request is a Beta Request, it was added to the Launcher Schedule. Thi acquire equipment status.



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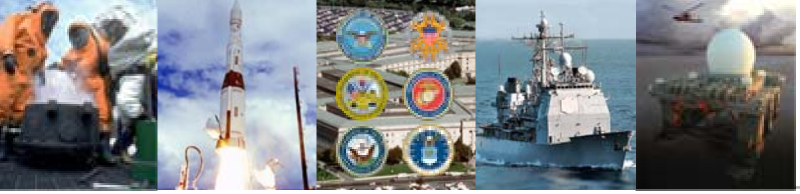
Class IlluminatorSchedule {Analysis}

Documentation

The IlluminatorSchedule contains all of the current illuminator reservations.

Parent Package	DomainObjects	**Abstract**	No



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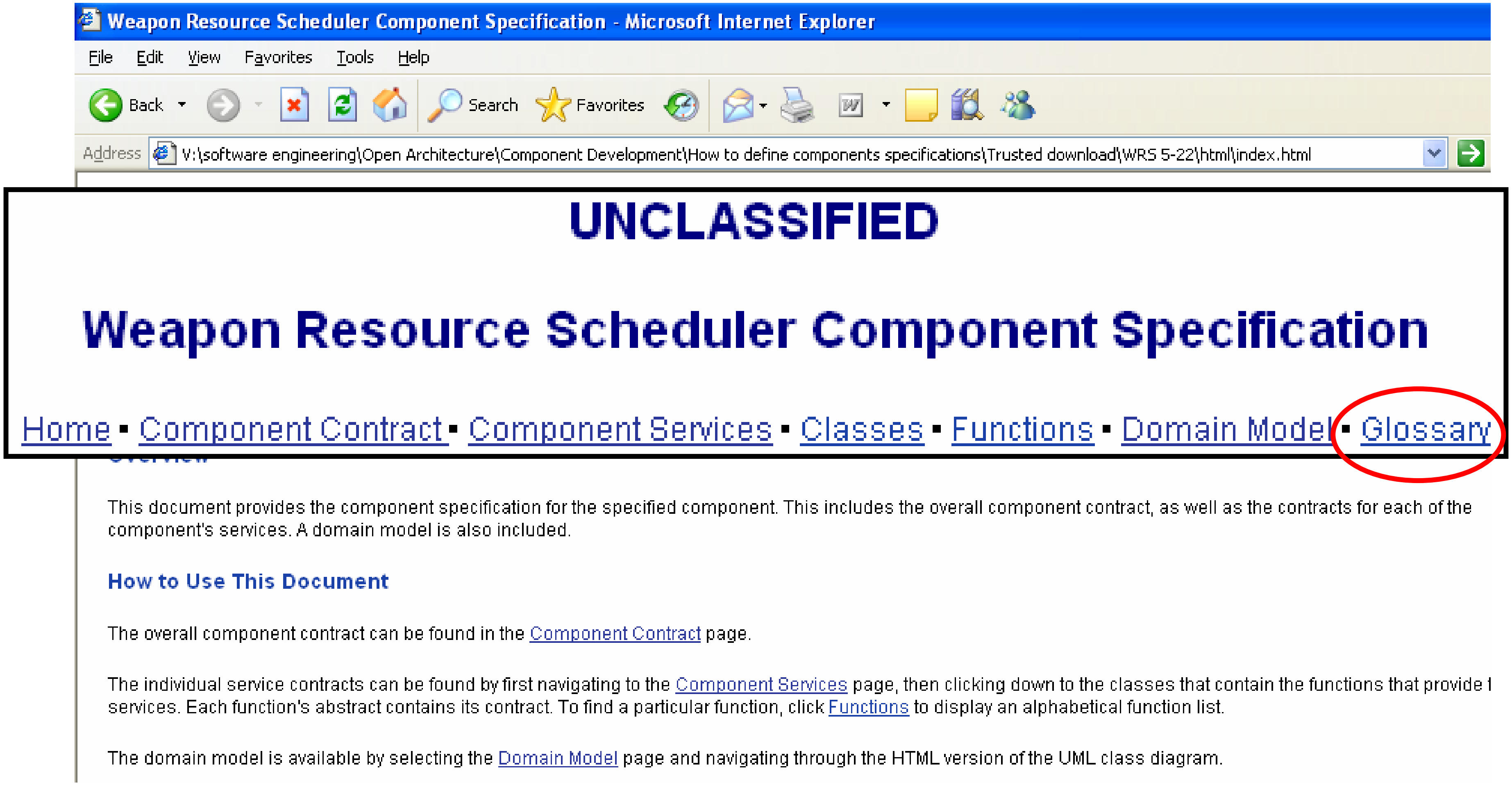
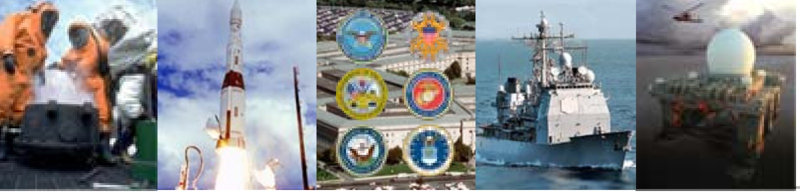




Glossary Excerpt

Component Contracts

Component contracts apply to the component as a whole. They should not be confused with **Component Service Contracts** which apply to particular services.

Precondition:

System and/or environment states required in order to successfully instantiate the component, e.g., config files must exist.

Postcondition:

Component states that exist upon completion of component instantiation and initialization. For OA, this includes completion of the component's start method. Examples of component level postconditions include:

- Indicating if the component was placed in active or standby state
- Listing which config files were read
- Stating that communications with other specific components were initialized
- Listing which subscriptions and publications were defined

Invariant:

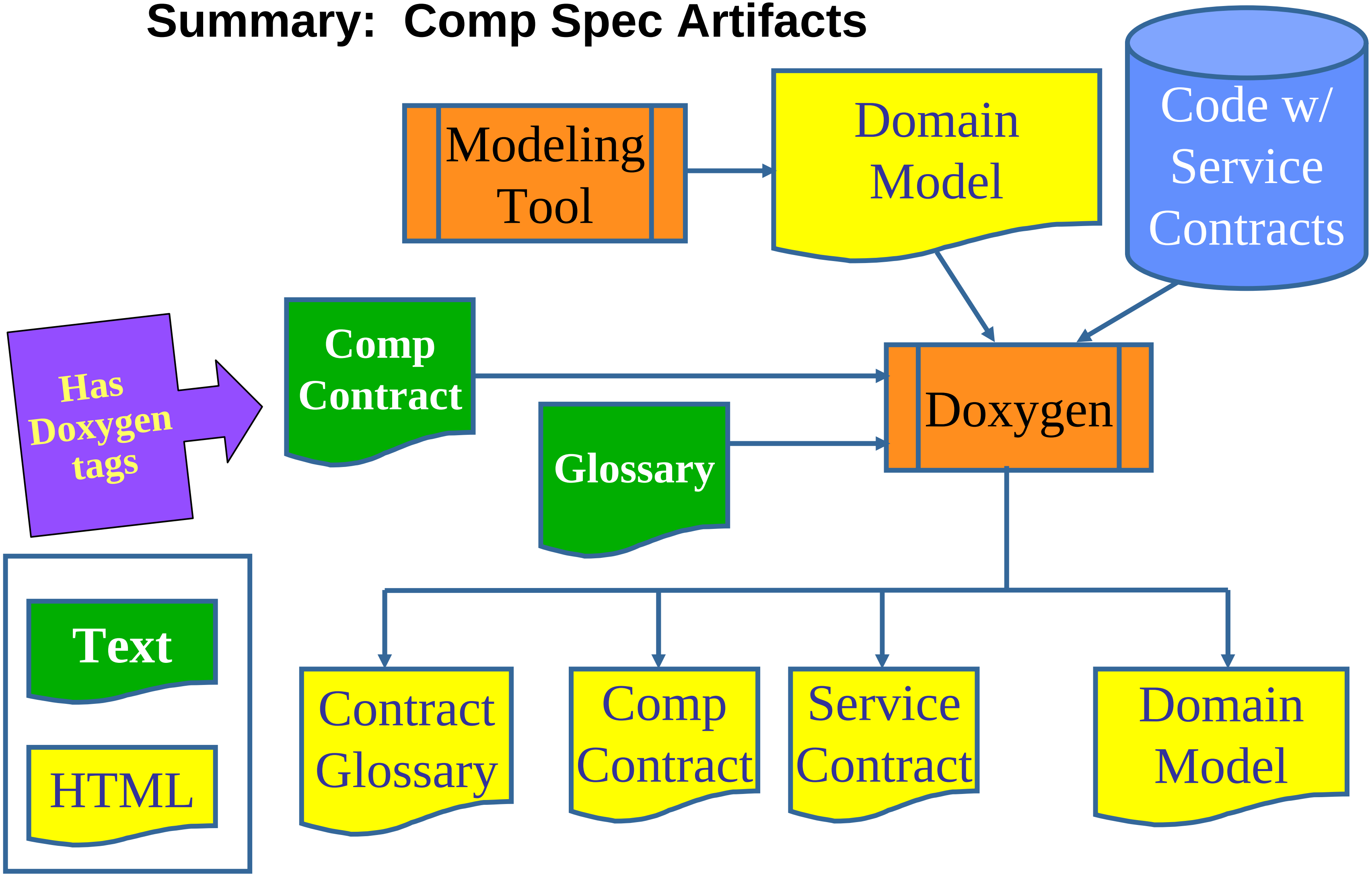
Component states that must be true after component instantiation/initialization **and** at the start and completion of any offered service. Multiplicity invariants are specified in the Domain Model (e.g., an Engagement may have between 0 and X weapons), so they should not be specified here. Note that when a service terminates due to exceptional behavior, part of the component's exception handling should insure that the invariant states are still true. If they are not true, the component should restore the invariant states. If this is not done, the component will be in an unstable state.

Exceptions:

NameOfException

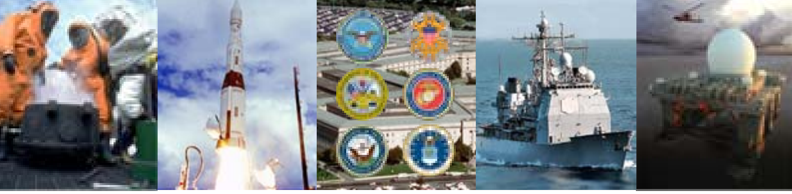
- What happens if component initialized when preconditions are not met.
- What happens if preconditions are met, but postconditions cannot be met.
- What happens if an invariant fails to be maintained.
- Notes
  - An exception is only handled if explicitly stated, otherwise component behavior is undefined.
  - "Exception" means behavior in the event of contract violation. It is not meant to imply that a C++

Summary: Comp Spec Artifacts



How This Technique Addresses Openness

- Provides *well-defined* interfaces using open paradigms
  - DbC and UML Domain Modeling
- Generated using open tools
- Output is readable in any HTML browser



What the Component Spec Provides

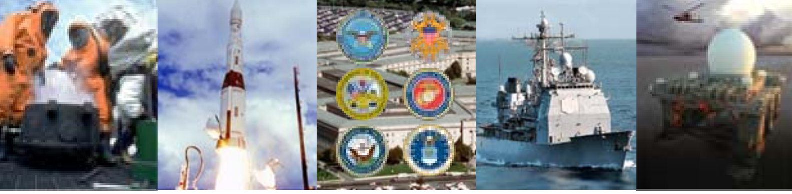
- Software Architect
  - Defines a component's role in overall architecture
  - Facilitates component reuse
- Software Developer
  - Defines implementation constraints
  - Describes exceptional behavior
- System Engineer
  - Facilitates understanding of the component's role in fulfilling requirements
- Component Test Engineers
  - Provides basis for writing component level tests

Lets the stakeholders know the rules

Level of Effort for Sample Component

- Task requires domain knowledge
  - *Does not need to be expert*, but does need access to an expert
- Documented 40 services
  - 28 trivial, e.g., getters/setters
  - 12 non-trivial
- 3.5 staff weeks

Writing specs takes time



For More Information

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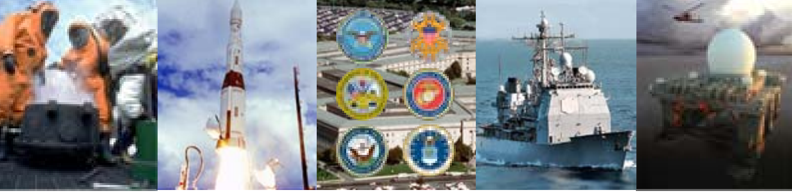
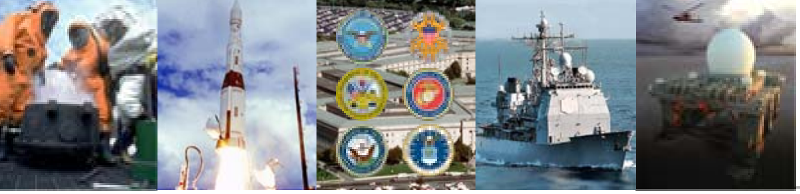


Backup

DbC Resources

- Larman, C., *Appying UML and Patterns: Introduction to OOA/D & Iterative Development, 3rd ed.* 2005: Prentice Hall.
- Szyperski, C., *Component Software: Beyond Object-Oriented Programming 2nd ed.* 2002: ACM Press.
- Mitchell, R. and McKim, J. *Design by Contract, by Example.* 2002: Addison-Wesley, Inc.
- Cheesman, J. and Daniels, J. *UML Components: A Simple Process for Specifying Component-Based Software.* 2001: Addison-Wesley, Inc.
- Hunt A. & Thomas D., *The Pragmatic Programmer*. 2000: Addison Wesley.
- Meyer, B. *Object-oriented Software Construction, 2nd ed.* 1997: Prentice Hall.
- http://archive.eiffel.com/doc/manuals/technology/contract/page.html
- http://ootips.org/lsp.html



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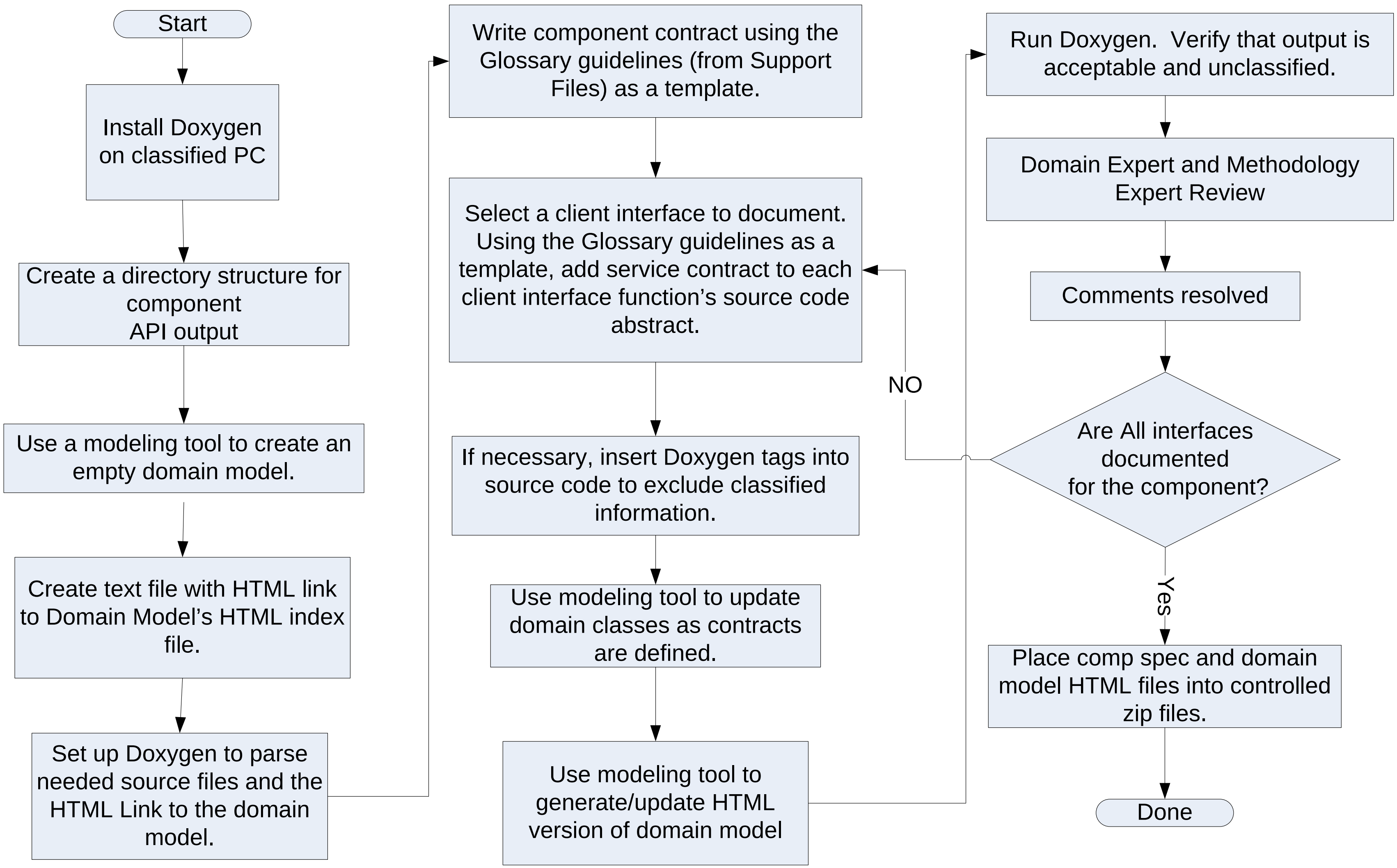
Comp Spec Development Process



OBIGGS II

Applying Systems Engineering to Large Improvement Project

On Board Inert Gas Generation System (OBIGGS)

- **Today I'll cover:**
  - **OBIGGS project**
  - **The state of Systems Engineering**
  - **SE implementation on project**
  - **Project results**

OBIGGS II Improvement Project

OBIGGS II

(US Air Force Photo)

OBIGGS II Improvement Project

OBIGGS II

(US Air Force Photo)

OBIGGS II Improvement Project

OBIGGS II

How the Team was Prepared to Work Together in Addressing the Project

BOEING

OBIGGS II

Executive Leadership

OBIGGS II DIRECTOR

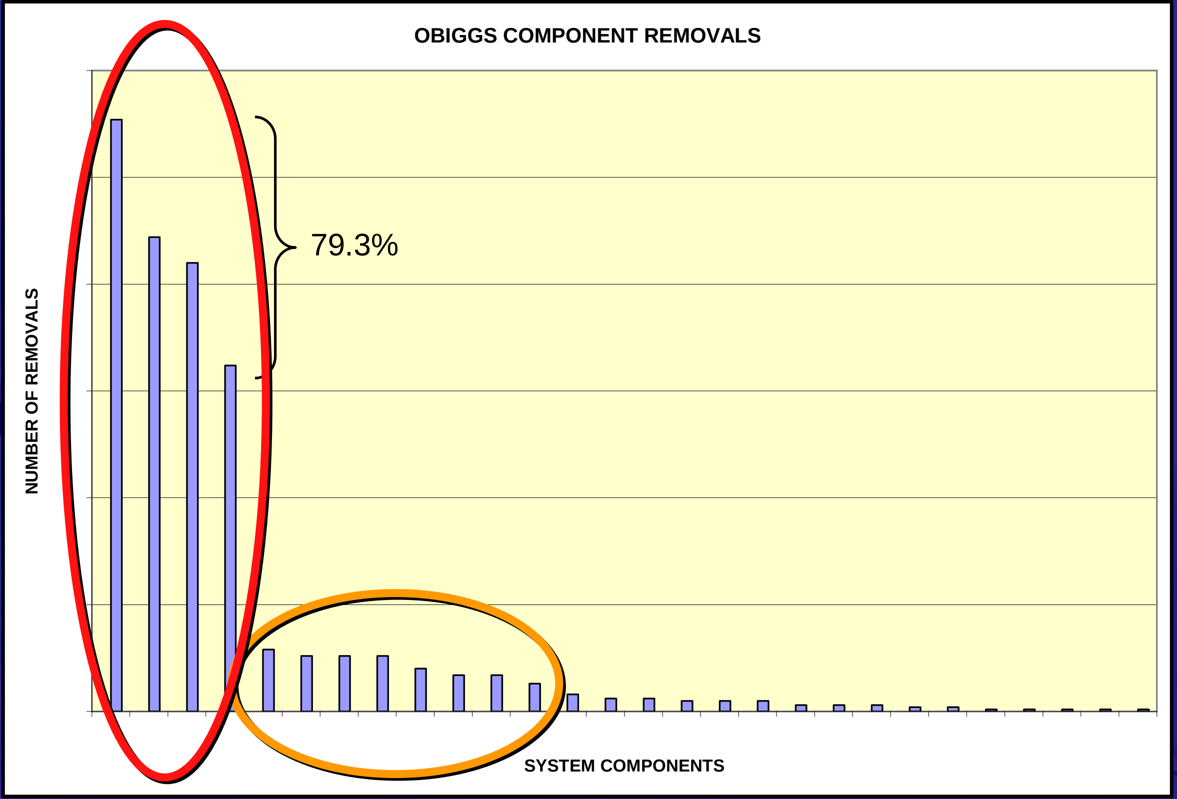
- Engineering
- Production
- Supplier Management
- Systems Engineering
- Training
- Field Services
- Flight Test

Team Co-located Facilities

Dedicated Personnel

Team Analysis of Data to Identify Possible Root Causes

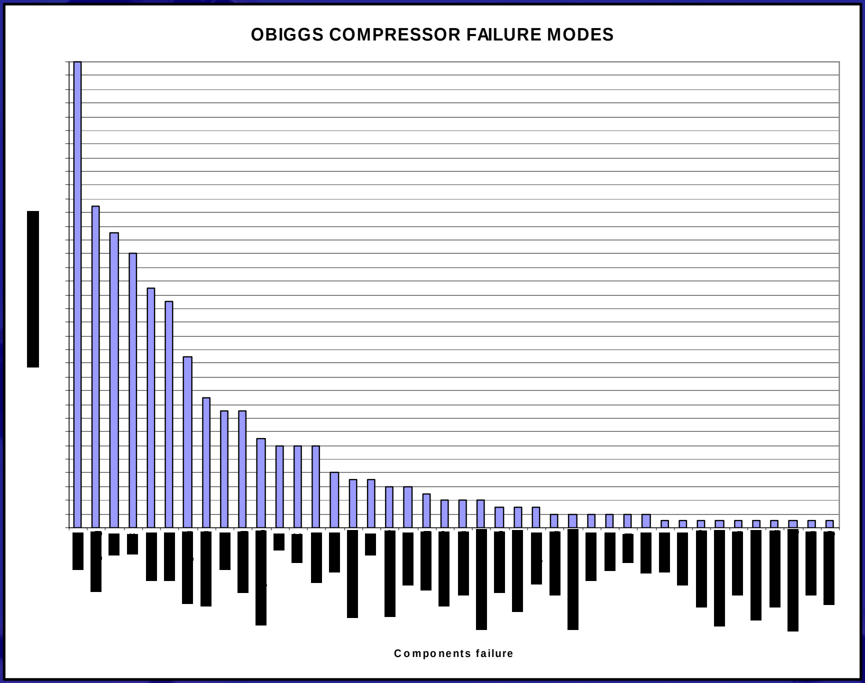
Pareto Analysis



4 main problem components were focus of initial improvement attempts

Team Analysis of Data to Select the Final Root Causes

Expanded Pareto analysis



Pareto results for just one of the driving components shows multiple issues

Identification of Root Causes and How the Team Validated the Final Root Cause

Final Root Cause :

The original design was inherently too complex and time consuming to fix to desired levels

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Affected Organizational Goals/ Performance Measures and Strategies

Value Creation

Profitably

Expand Markets

Operational Efficiency

Customer Solutions

Stakeholder Requirements & Expectations

- Customer
- Work Force
- Suppliers
- Community
- Shareholders

Run Healthy Business

- Achieve aggressive, sustainable improvements to safety, quality, schedule and cost
- Strengthen stakeholder relationships
- Relentlessly improve and integrate processes

Leverage to Emerging Opportunities

- Aggressively pursue a sustainable competitive advantage
- Capture additional C-17 business (C-17, BC-17X, International)
- Launch C-17A+
- Capture Performance Improvement contracts
- Expand alliances and partnerships

Create New Frontiers

- Create Agile Logistics Mobility and Systems Solutions
- Create Next Generation Airlift/Support
- Create Network-Centric Capability Integration
- Accelerate Technology Integration

Our Vision:

People Working Together to Provide the World's First Choice for Global Airlift and Mobility Solutions

Time

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OBIGGS II

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Time

Affected Internal and External Stakeholders and How they were Identified

OBIGGS II

Stakeholders

- **Internal**
  - Engineering
  - Production
  - Supplier Management
  - Support Systems
  - Training
  - Field Services
  - Flight Test
- **External**
  - Pilots
  - Maintainers
  - Customer Engineering
  - Suppliers

How Affected Stakeholders were Identified

- **Internal stakeholders identified via project management process at kick-off meeting**
- **External customer stakeholders identified by Boeing Field Services and USAF engineering customers**
- **External supplier stakeholders identified through competitive bid process**

How the Team Members were Selected and Involved Throughout the Project

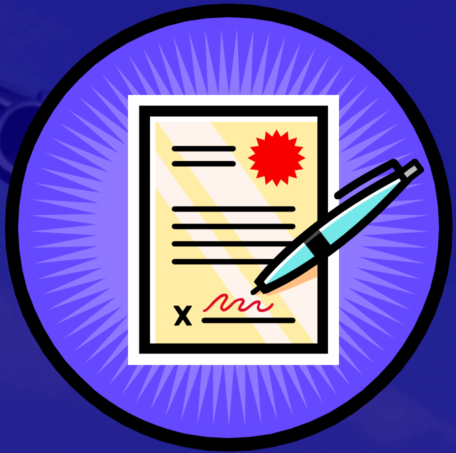
OBIGGS II

Representatives identified within each organization

Internal customers

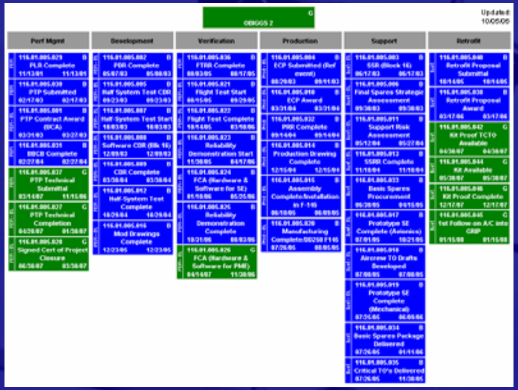
Suppliers

Air Force customer



How the Team Members were Selected and Involved Throughout the Project

Involvement was maintained by establishing ownership from each team member and matching skills with needs



Agreed to team plans

Supplier partnerships

Control account responsibility

How the Team was Prepared to Work Together in Addressing the Project

Training Class	Benefit
System Engineering Workshop	Requirements definition
Model Based Definition	Eliminate 2-D drawings
Earned Value Management	Performance and Cost control
Integrated Performance and Scheduling	Schedule adherence
Employee Involvement	Address barriers as a team
Accelerated Improvement Workshops	Tool use for root cause analysis

OBIGGS II

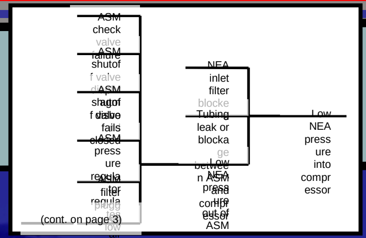
How the Team was Prepared to Work Together in Addressing the Project

REVIEW	OCCURRENCE	ATTENDEES
Project Team Stand-Up	Daily	Internal – Supplier Management, Systems Engineering, Project Management
Action item review	Weekly	Customer, Project management
Program review	Weekly	Internal Stakeholders
Technical Interchange	Bi-monthly in person	Customer, Project management
Internal project review	Bi-monthly	Boeing executive leadership
Program review	Bi-Monthly video conference	Boeing and customer executive leadership

Open communication was emphasized and key to project success!

Methods and Tools Used to Develop Possible Solutions

OBIGGS II



Fault Tree Analysis

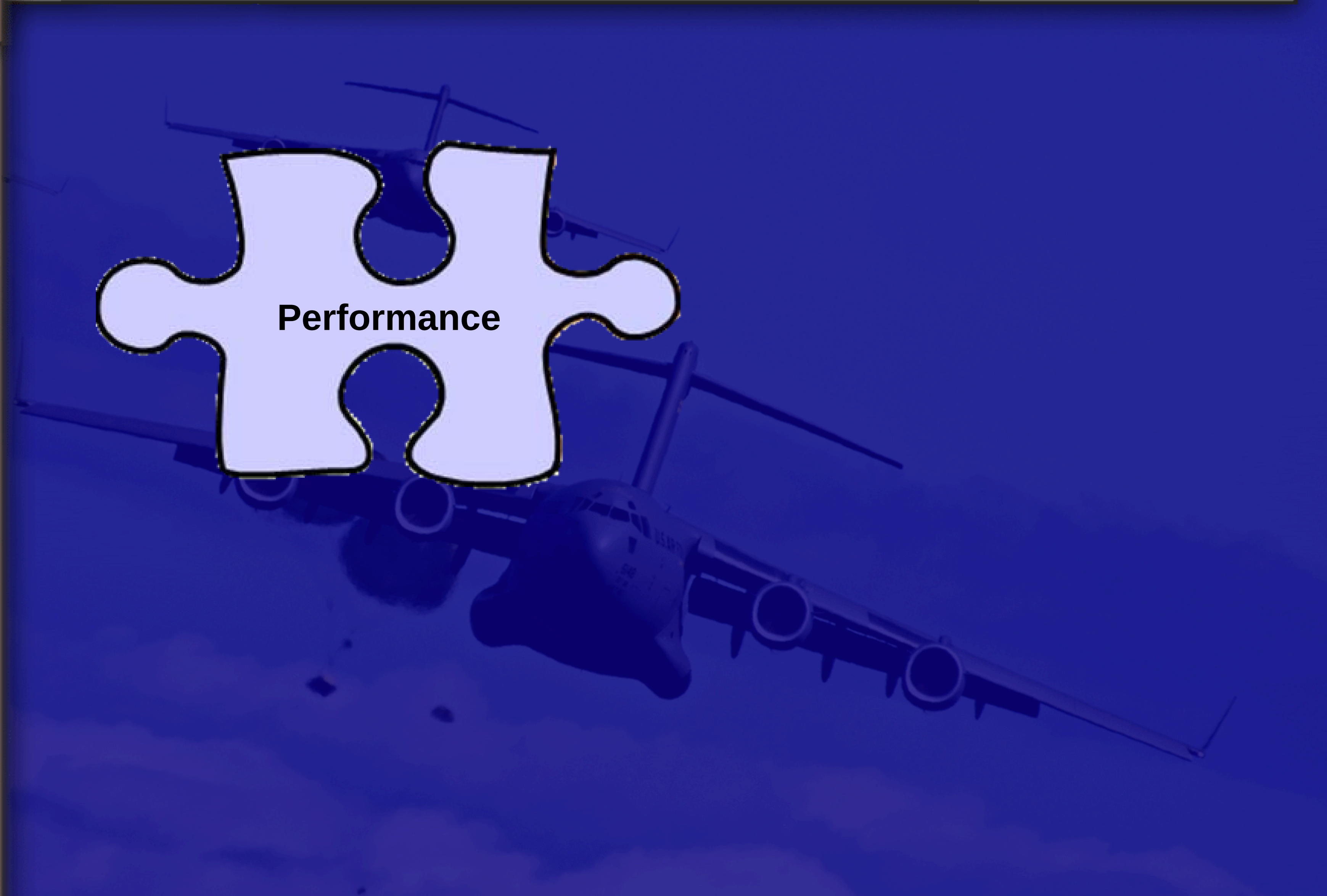
Brainstorming

Benchmark Suppliers

Possible Solutions

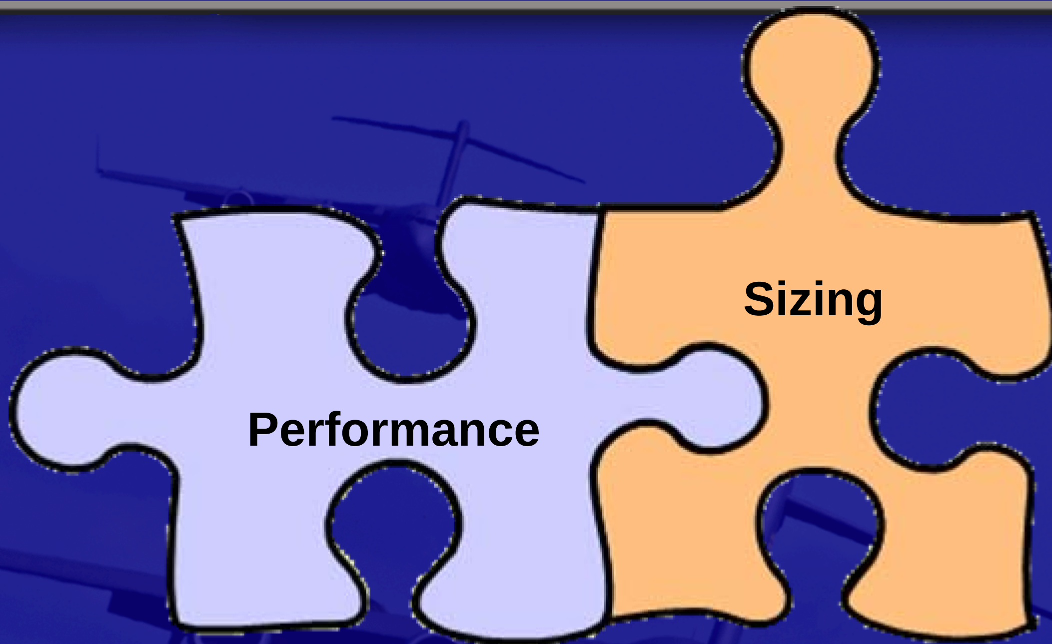
Team Analysis of Data to Develop Possible Solutions

OBIGGS II



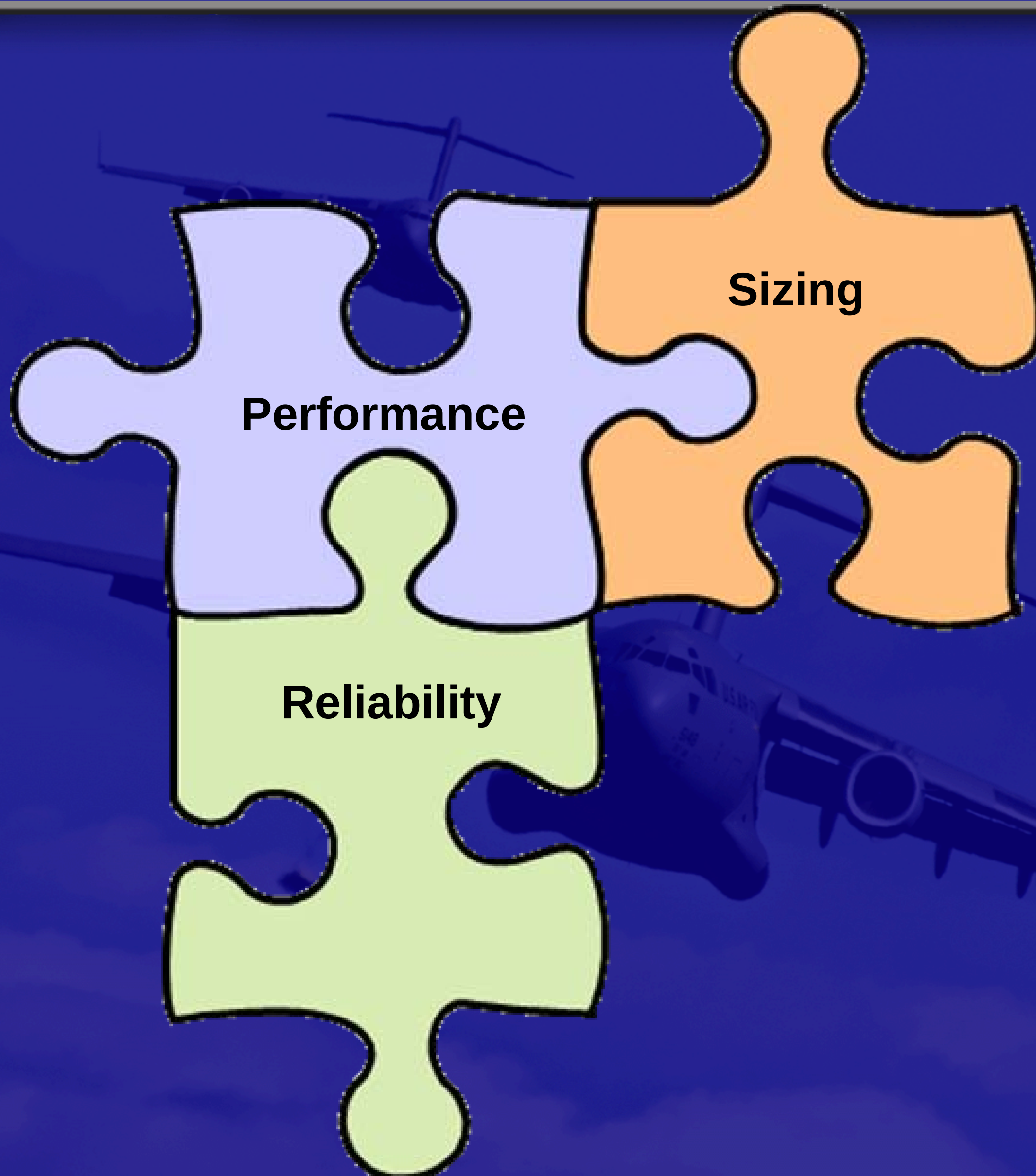
OBIGGS II

Team Analysis of Data to Develop Possible Solutions

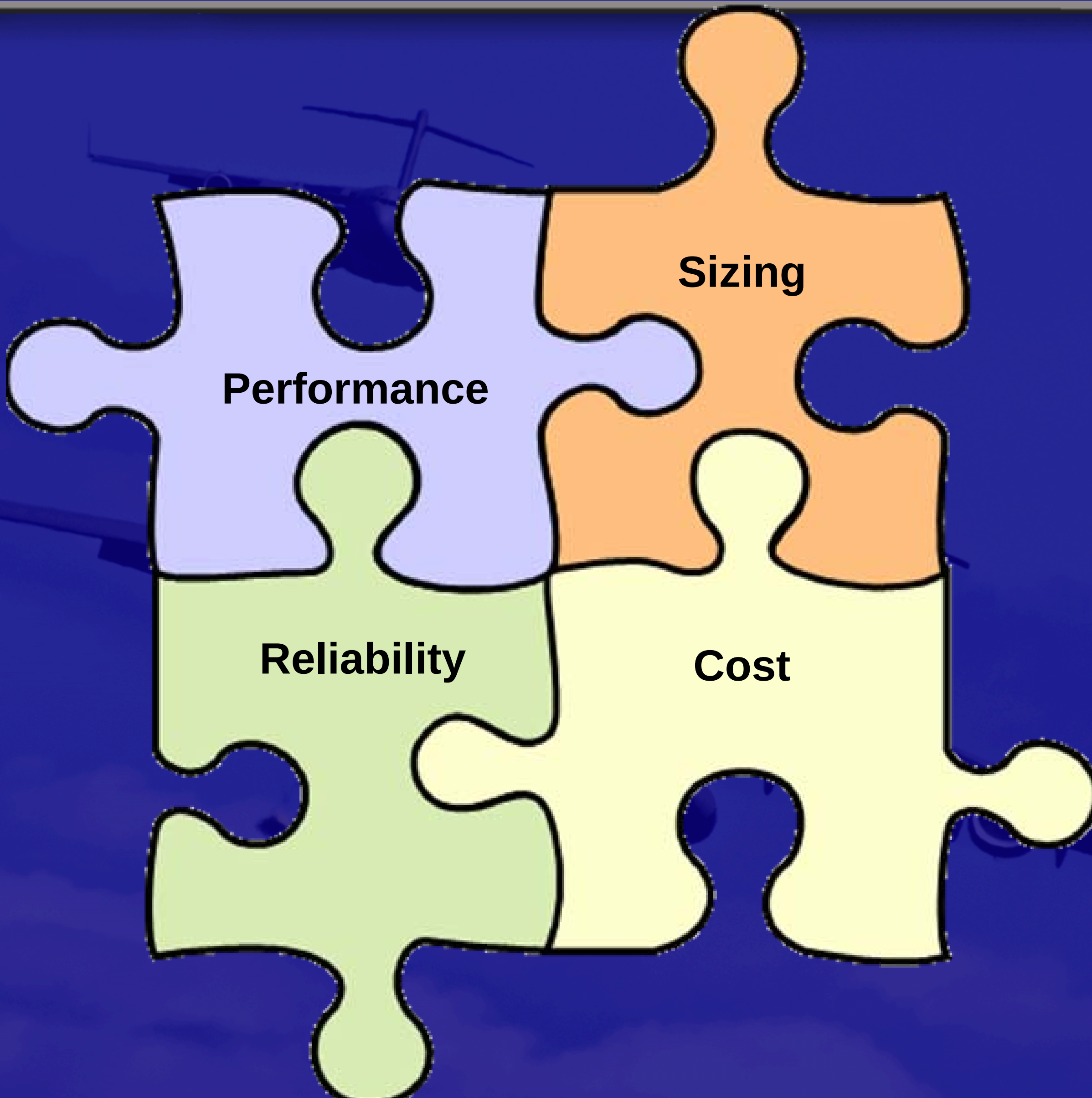


OBIGGS II

Team Analysis of Data to Develop Possible Solutions



Team Analysis of Data to Develop Possible Solutions



Criteria the Team Decided to Use in Selecting the Final Solution

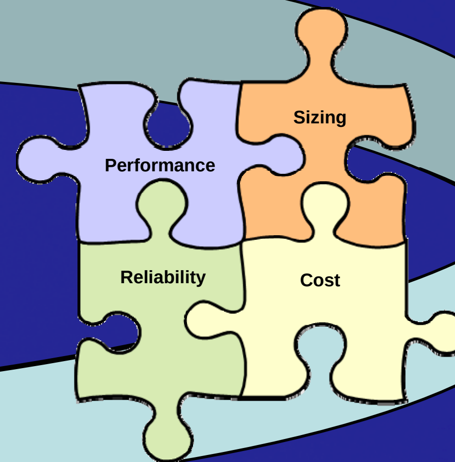
Design Requirements	5	3	1
1. Supports tank volume of [redacted] cu ft	Supports > [redacted]		Supports < [redacted]
2. Maintain tank and vent system inert through all mission profiles	Tanks and vent inert through all profiles	Tanks inert through all profiles, vents most	Tanks and vents inert through most profiles
3. Total engine flow within limits	< [redacted] %		> [redacted] %
4. Initialization time < [redacted] min.	t < [redacted] min.	[redacted] min.≤ t < [redacted] min.	[redacted] min. ≤ t
5. Mean-Time Between Maintenance, corrective	MTBMc > [redacted] hrs	[redacted] hrs ≤ MTBMc ≤ [redacted] hrs	MTBMc < [redacted] hrs
6. Life Cycle Costs	LCC ≤ 90% of current	90% of current < LCC < current	LCC ≥ Current
7. No increase in pilot workload	Decrease in workload	Same workload	Slight increase in workload
10. Qualified components	Qualified	Partially qualified	Not qualified
11. Fuel tank pressures	Meets pressure settings		Doesn't meet pressure settings
12. Single ASM failure does not limit mission capability	All missions possible	95% of missions still possible	90% of missions still possible
13. Detect individual LRU failures	LRUs identified and isolated by BIT	Failures identified, but fault tree required for isolation	Periodic ops checks and isolation required
14. Capable of inert [redacted] fpm descent with any single failure	[redacted] fpm possible with all single failure types	[redacted] fpm possible with all except [redacted] failure types	[redacted] fpm possible with all except > [redacted] failure types
15. No two failures cause critical structural failure or prevent recovery	No critical double failures		Critical double failures exist
16. No Real Hazard I>11	All RHIs < 8	8 ≤ RHIs < 11	Some RHIs ≥ 11
17. Current cockpit philosophy	Integrated	Pseudo Integrated	Not integrated
18. Capability of retrofit	Easy retrofit	Hard to retrofit	Can't retrofit
20. General design practices	Design standards followed in all areas	Design standards followed in most areas	Design standards followed in some areas
21. Production Cost Savings	CS > $[redacted]K	$[redacted]K < CS ≤ $[redacted]K	CS ≤ $[redacted]K

Note: Sensitive data blocked out

Methods and Tools Used by the Team to Select the Final Solutions

Possible Solutions

Assembled Stakeholder Team



Presented Analysis

Design Requirements	5	3	1
1. Supports tank volume of [redacted] cu ft	Supports > [redacted]		Supports < [redacted]
2. Maintain tank and vent system inert through all mission profiles	Tanks and vent inert through all profiles	Tanks inert through all profiles, vents most	Tanks and vents inert through most profiles
3. Total engine flow within limits	< [redacted] %		> [redacted] %
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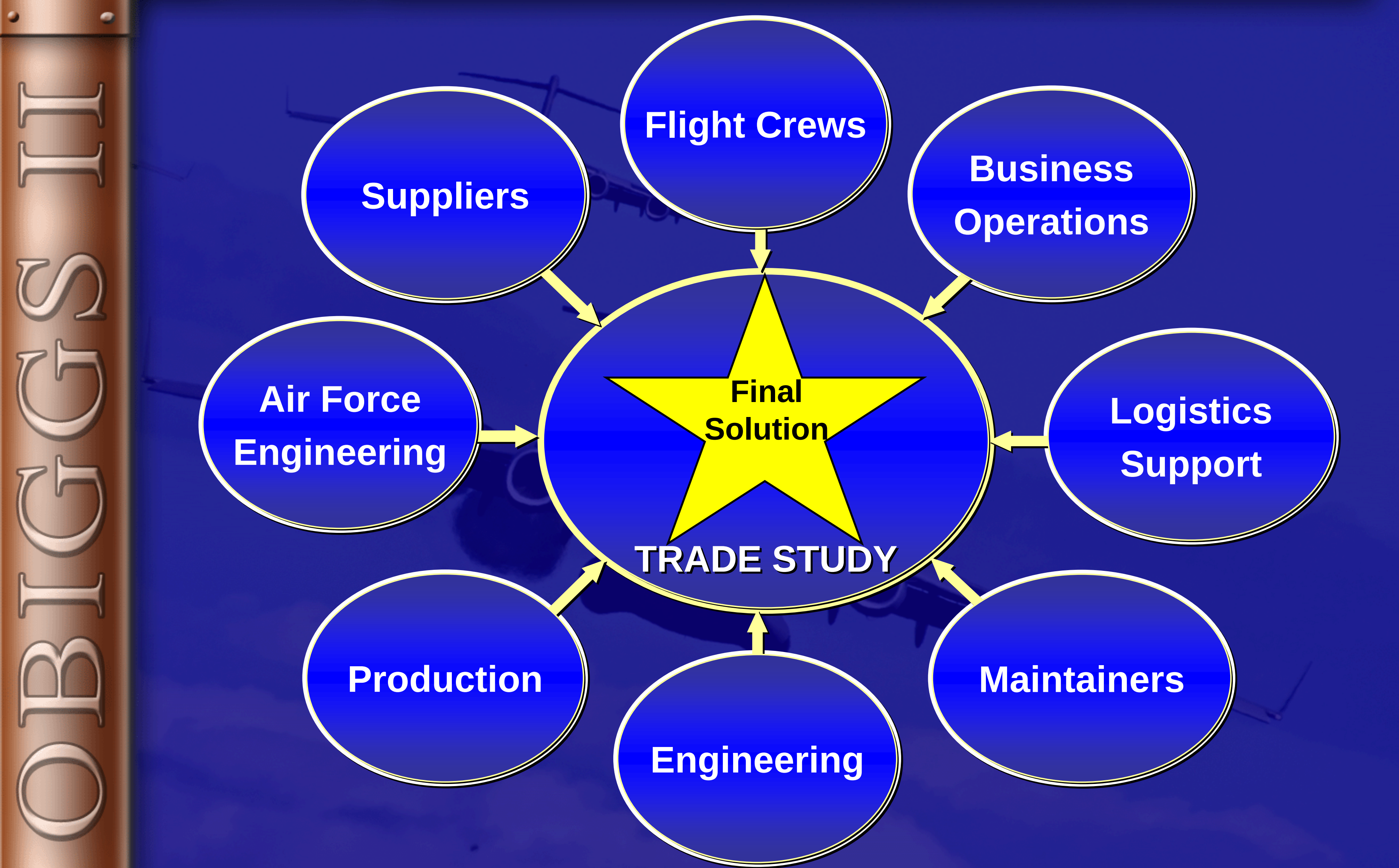
Performed Trade Study

Final Solution

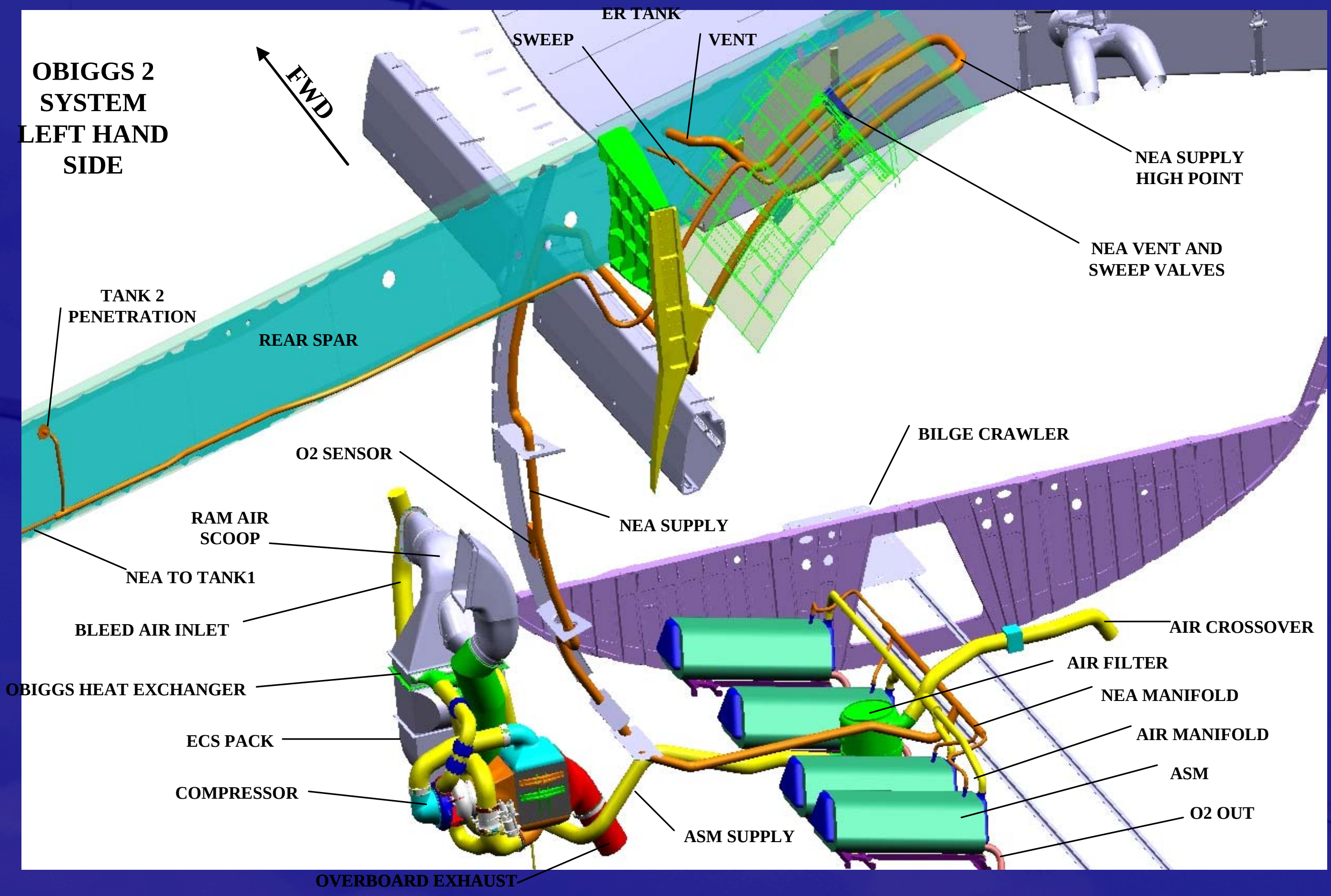
OBIGGS II

Involvement of Stakeholders in the Selection of the Final Solution



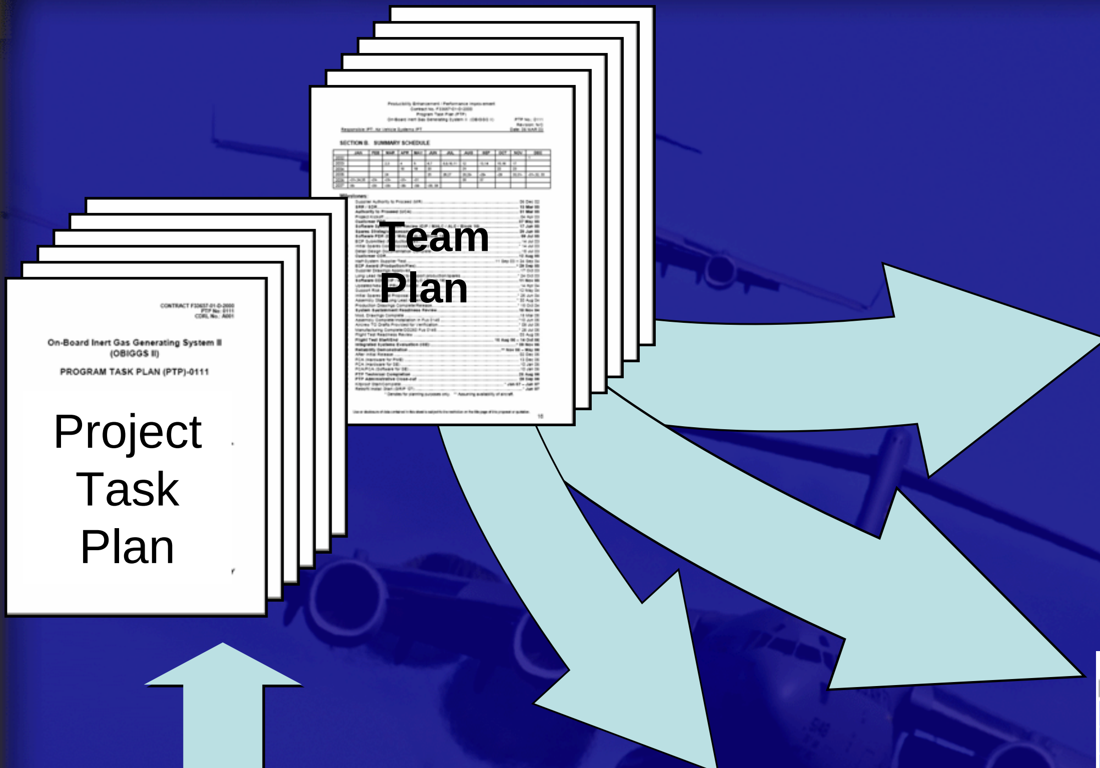
Functional Analysis

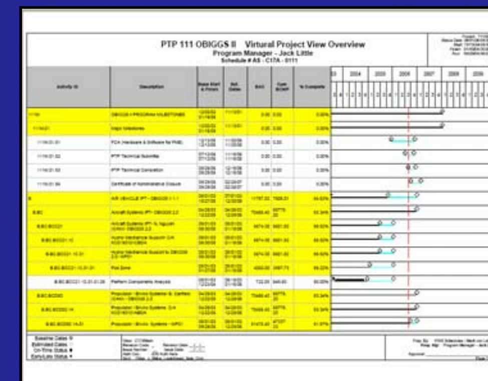
OBIGGS II



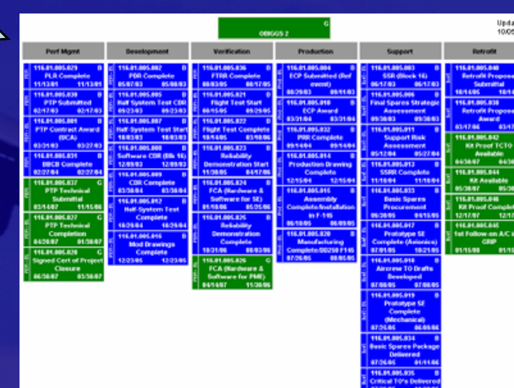
Risk Management

Plan Developed by the Team to Implement its Solution





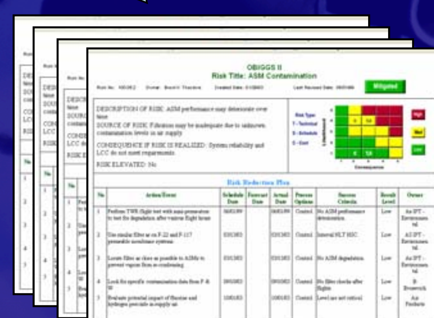
Integrated Master Schedule



Integrated Master Plan

Stakeholders	Types of Impact
Internal	
Engineering	Create 750 new drawings for system and support equipment
Production	Plan, install, and test new system components
Supplier Management	Procure 1400 new parts
Support Systems	Create tech manuals and provision spares
Training	Create new training course
Field Services	Prepare to assist USAF maintenance
Flight Test	Install instrumentation and verify new system performance
External	
Pilots	Understand display changes and reduced initialization time
Maintainers	Use new maintenance procedures
Customer Engineering	Monitor project performance/verify specification compliance
Suppliers	Design and deliver new system components

Stakeholders



Risk Mitigation Plans

OBIGGS II

How the Team Members were Selected and Involved Throughout the Project

Identified functional impacts within each department

- Work Breakdown Structure created
- Detailed Statement of Work created

PROJECT/PROGRAM	WORK BREAKDOWN STRUCTURE DICTIONARY	DATE: 12/02/99 REVISION: 1
C-17	OBIGGS REDESIGN	PAGE: 01
John C. Hsu (982-6359)	TOTAL PROGRAM	S.O.W. NO./PARA. 3.2

WBS LEVEL	ELEMENT TITLE
1 2 3 **4** 5 6 7 8	Environmental Systems
E.S.O.W. 3.2.1	Trade Study

ELEMENT DESCRIPTION

3.2.1 Perform trade study
3.2.1.1 Define customer requirements (Use actual)
3.2.1.2 Define system requirements (Use actual)
3.2.1.3 Identify candidate systems (Use actual)
3.2.1.4 Define QFD relationships (Use actual)
3.2.1.5 Define customer weights (Use actual)
3.2.1.6 Establish scoring criteria (Use actual)
3.2.1.7 Rank candidate systems (Use actual)
3.11.15.1 Update/Monitor customer, systems, design and derived requirements
3.11.15.2 Sub-systems/components trade study

EFFORT REQUIRED

WBS LEVEL	ASSOCIATED LOWER LEVEL ELEMENTS TITLE
1 2 3 4 **5** 6 7 8	Systems Engineering/Design Office

Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Hrs	30	30	30	20	20	20	20	20	5	5	5	5												

REVISION APPROVAL: PROGRAM OFFICE/DATE

Producibility Enhancement / Performance Improvement
Contract No. F33657-01-D-2000
Program Task Plan (PTP)
On-Board Inert Gas Generating System II (OBIGGS II) PTP No.: 0111
Revision: N/C
Responsible IPT: Air Vehicle Systems IPT Date: 06 MAR 03

SECTION B. SUMMARY SCHEDULE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2002												1
2003			2,3	4	5	6,7	8,9,10,11	12	13,14	15,16	17	
2004				18	19	20		21		22	23	
2005			24			25	26,27	28,29-	-29-	-29	30,31-	-31-,32, 33
2006	-31-,34,35	-31-	-31-	-31-	-31			36	37			
2007	38-	-38-	-38-	-38-	-38-	-38, 39						

Milestones:
1.0 Supplier Authority to Proceed (MR) .... 06 Dec 02
2.0 SRR / SDR .... 13 Mar 03
3.0 Authority to Proceed (UCA) .... 31 Mar 03
4.0 Project Kickoff .... 04 Apr 03
5.0 Customer PDR .... 07 May 03
6.0 Software Specification Review (CIP / MALC / ALC / Block 16) .... 17 Jun 03
7.0 Spares Strategic Assessment .... 29 Jun 03
8.0 Software PDR (CIP / MALC / ALC / Block 16) .... 09 Jul 03
9.0 ECP Submitted (Production/Flex) .... 14 Jul 03
10.0 Initial Spares Cost Proposal Submitted .... * 14 Jul 03
11.0 Detail Design Documentation Complete .... 15 Jul 03
12.0 Customer CDR .... 12 Aug 03
13.0 Half-System Supplier Test .... 11 Sep 03 – 24 Sep 04
14.0 ECP Award (Production/Flex) .... * 29 Sep 03
15.0 Supplier Drawings Approved .... 17 Oct 03
16.0 Long Lead Items Ordered to support production/spares .... * 24 Oct 03
17.0 Software CDR (CIP / MALC / ALC / Block 16) .... 11 Nov 03
18.0 Updated/New SE PRU Delivered .... 14 Apr 04
19.0 Support Risk Assessment .... 12 May 04
20.0 Initial Spares Cost Proposal Award .... * 25 Jun 04
21.0 Assembly Start (Long Lead Assembly) .... * 30 Aug 04
22.0 Production Drawings Complete/Release .... * 15 Oct 04
23.0 System Sustainment Readiness Review .... 18 Nov 04
24.0 Mod. Drawings Complete .... 18 Mar 05
25.0 Assembly Complete/Installation in Fus 0145 .... *10 Jun 05
26.0 Aircrew TO Drafts Provided for Verification .... * 08 Jul 05
27.0 Manufacturing Complete/DD250 Fus 0145 .... * 26 Jul 05
28.0 Flight Test Readiness Review .... 03 Aug 05
29.0 Flight Test Start/End .... 15 Aug 05 – 14 Oct 05
30.0 Integrated Systems Evaluation (ISE) .... * 09 Nov 05
31.0 Reliability Demonstration .... ** Nov 05 – May 06
32.0 After Initial Release .... 02 Dec 05
33.0 FCA (Hardware for PME) .... 13 Dec 05
34.0 FCA (Hardware for SE) .... 10 Jan 06
35.0 FCA/PCA (Software for SE) .... 10 Jan 06
36.0 PTP Technical Completion .... 25 Aug 06
37.0 PTP Administrative Close-out .... 29 Sep 06
38.0 Kitproof Start/Complete .... * **Jan 07 – Jun 07**
39.0 Retrofit Install Start (GRIP '07) .... * **Jun 07**

* Denotes for planning purposes only. ** Assuming availability of aircraft.

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16

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How the Team Managed its Performance to Ensure it was Effective as a Team

OBIGGS II

OBIGGS II CCB# IC040215
PROJECT PERFORMANCE

Financials Updated 09/26/06
11 Panel Updated 10/05/06

Aug 06 ME

Target Cost	BCWS	BCWP	ACWP	BAC	EAC	%COMP$_{BAC}$	% SPENT$_{BAC}$
[redacted]	[redacted]	$[redacted]	$[redacted]	$[redacted]	$[redacted]	97.44%	96.83 %

Calculations:

CPI = 1.00
SPI = 1.00
Schedule Variance = $[redacted]
Schedule Variance % = 0.02%

$TCPI_{EAC}$ = .48
EAC>BAC Ratio = 1.00
Cost Variance = $[redacted]
Cost Variance % = 0.35%

PRA=$110K

Systems Group Lead:

Boeing Lead:

Aug 06 Ratings

Performance Status	Rating R/Y/G	Issues / Comments
(01) Technical Performance Measures	G	
(02) System Engineering	G	
(03) Performance to Change Implementation Plan	B	
(04) Configuration Compliance	G	
(05) Support Systems	B	
(06) Training	B	
(07) Schedule	G	
(08) Cost Performance	G	
(09) Expenditures / ROI	G	
(10) Supplier Performance	Y	10.01 - Schedule Performance Index (SPI): SPI = 0.99. Some performance for completed work was not taken because of late receipt of an invoice from one supplier. Will be corrected in October
Project Manager Overall Assessment - August	G	
Project Manager Overall Assessment - Forecasted September	G	
Project Manager Overall Assessment - Forecasted October	G	

Note: Sensitive data blocked out

SUCCESSFUL PROJECT PERFORMANCE RESULTS FROM EFFECTIVE TEAM MANAGEMENT AND ACTION TO RESOLVE ISSUES EARLY

INDIVIDUAL ACCOUNTS MONITORED WEEKLY FOR COST AND SCHEDULE PERFORMANCE

Element	Description	Current SPI	Current CPI	Cum SPI	Cum CPI	TCPI	ariance npletion	Current Sch Var	Current Cost Var	Cum Sch Var	Cum Cost Var
KC01901012BDA	ECP PROPOSAL PREP - ALL EXCE	1	0.61	1	0.65	1.04	-24	0	-7	0	-24
KC01901013BDA	AVIONICS /FLIGHT CONTROL INTE	-2	-2	0	n/a	1.03	0	-3	-4	-3	-1
KC01901014BDA	AVIONICS - HSC/LFCP/RIU/MMP, A	4.09	4.5	1.31	3.59	0.78	-3	35	35	24	70
KC01901015BDA	PTP 111 OBIGGS 2.0 - FUSE DESI	0.15	0.33	0.21	0.41	1.07	0	-22	-8	-60	-23
KC01901016BDA	AF: PTP111 OBIGGS 2.0 STANDAR	1	0.78	1	1.22	0.95	0	0	-2	0	4
KC0190101ABDA	PROPULSION / ENVIRONMENTAL	0.22	0.09	0.79	1.13	0.96	-53	-194	-576	-292	129
KC0190101BBDA	PROPULSION / ENVIRONMENTAL	-5.47	-3	0	n/a	1.06	-14	-221	-249	-221	-102
KC0190101CBDA	PTP-111, OBIGGS 2.0 - HYDRO-M	1.15	1.21	1.03	0.98	1.01	0	3	4	3	-2
KC0190101DBDA	PTP-111 OBIGGS 2.0 - ELECTRIC	0.91	0.98	0.8	0.92	1.02	-1	-6	-1	-74	-26
KC0190101EBDA	PTP111 OBIGGS 2.0-SUPPLIER SV	1	0.67	1	1.08	1	0	0	-2	0	1
KC0190101FBDA	SYSTEM INTEGRATION LABS OBIC	0	n/a	0	n/a	1.01	-2	-32	-6	-79	-11
KC0190101GBDA	PTP111 OBIGGS 2.0-AVIONICS SW	0	n/a	0.92	1.75	0.91	0	-168	-183	-45	228
KC0190101HBDA	PTP 111 OBIGGS 2.0 - AVIONICS	0.23	0.03	1.3	1.22	0.9	0	-20	-202	74	58
KC0190101JBDA	PTP 111 OBIGGS 2.0 - FUSE STRE	1.4	2.33	0.67	1.2	0.99	-1	3	4	-6	3
KC0190101KBDA	PTP 111 OBIGGS 2.0 - WING STRU	0.53	0.53	0.81	0.83	1.02	0	-7	-7	-8	-8
KC0190101LBDA	AV/SS I & DO: PTP111 OBIGGS 2.	1	1.17	1	1.83	0.94	0	0	1	0	14
KC0190101MBDA	AV/SS I & DO: PTP111 OBIGGS 2.	1	0.29	1	1.16	0.96	-2	0	-16	0	6
KC0190101NBDA	SE & OP/TOOLS: PTP111 OBIGGS	1	0.3	1	0.77	1.13	-1	0	-73	0	-34
KC0190101PBDA	AVIONICS /FLIGHT CONTROL INTE	1	1	0.2	0.5	1.19	5	-1	0	-5	-1
KC0190101RBDA	PTP 111 OBIGGS 2.0 - SW QA	1	0.8	1	0.93	1	0	0	-2	0	-2
KC0190101TBDA	SYSTEM INTEGRATION LABS OBI(	1	0.33	1	0.33	1.01	0	0	-2	0	-6
KC0190101VBDA	AV/SS I & DO: PTP111 OBIGGS 2.	1	0.53	1	1.21	0.94	-2	0	-22	0	19
KC0190101WBDA	SYS INTEG LABS OBIGGS II SERV	1	0	1	7.67	0.9	0	0	8	0	20
KC0190101XBDA	PTP 111 OBIGGS 2.0 - SUPP EQUI	0	n/a	0.53	0.5	1.13	0	-30	-36	-43	-51
KC0190101YBDA	PTP 111 OBIGGS 2.0 - SUPP EQUI	0	n/a	0.08	0.5	1	-2	-1	0	-21	-1
KC0190101ZBDA	PTP 111 OBIGGS 2.0 - CHNG MGM	1	1.86	1	1.79	0.95	-1	0	6	0	19
KC01901020BDA	PTP111 OBIGGS II - ECP PROPOS	1	0.17	1	0.42	2.17	0	0	-5	0	-8
KC01901021BDA	PTP111 OBIGGS II - LSCA/LCC &	0.1	1	0.13	1	1	0	-9	0	-34	0
KC01901022BDA	OBIGGS II - SUPPORT SYSTEMS F	1	1	1	1.11	0.99	0	0	-1	0	3
KC01901023BDA	OBIGGS II - SUPPORT ANALYSIS	0	n/a	0.42	0.63	1.02	0	-6	-1	-14	-5
KC01901024BDA	OBIGGS II - TRAINING IPT INTEG	1	0	1	3	0.88	0	0	1	0	2
KC01901025BDA	PTP 111 OBIGGS II PROVISIONING	n/a	n/a	0	n/a	1.05	-1	0	0	2	-2
KC01901026BDA	OBIGGS II - TECHNICAL PUBLICAT	n/a	n/a	n/a	n/a	1	0	0	0	0	0
KC01901028BDA	OBIGGS II - TYPE 1 TRAINING	n/a	n/a	0	n/a	0.98	0	0	0	-1	0
KC01901030BDA	PTP111 OBIGGS 2 - C13 LABOR	1	16	1	1.5	0.56	-12	0	15	0	22
KC01901031BDA	PTP 111 ASSY SUPT PLNG PKG	n/a	n/a	n/a	n/a	0.09	-223	0	-18	0	-20
KC01901040BDA	PTP 111 OBIGGS 2.0 BUYERS LAE	1	1.13	1	0.83	1.05	0	0	2	0	-15
KC01901041BDA	PTP 111 OBIGGS 2.0 BUYERS LAE	1	0.76	1	1.56	0.84	-2	0	-3	0	18
KC01901050BDA	PTP 111 OBIGGS 2.0 FLT OPS	1	0.5	1	2.5	0.75	0	0	-1	0	3
KC01901060BDA	PTP 111 OBIGGS 2.0 AVIONICS MA	1	0.24	1	1	1	0	0	-1,429	0	0
KC01901061BDA	PTP 111 OBIGGS AIRFRAME MATE	n/a	0.38	0.42	1	1	0	60	-100	-642	0

OBIGGS II

Types of Internal and External Stakeholder Involvement in Implementation

FORMAL DESIGN REVIEWS

- System Requirements Review
- System Design Review
- Preliminary Design Reviews (Supplier and Customer)
- Critical Design Reviews (Supplier and Customer)

Teamwork

DESIGN FOR MANUFACTURING AND ASSEMBLY

- Assembly Simulations
- Prototype Fit Checks on Aircraft
- Document Quality Inspections

PRODUCTION SUPPORT

- Proactive Issue Resolution
- First Article Inspections

Communication

VALIDATION / VERIFICATION

- Combined Validation/Verification Component Reviews
- Flight Test
- In Service Evaluation

OBIGGS II

How Stakeholder Buy-in Was Ensured

Stakeholders	Plan to Ensure Buy-in:	Validated By:
Engineering	Developing own implementation plans. Reported progress to them regularly.	Dedicated support to the project. Commitment to plan evident during regular status reviews.
Production	Early involvement for development of installation plans. Collocated engineers on first assembly. Full scale mockups of large parts.	Requests for manufacturing features on designs. Strong participation in mockup trial installations. Positive feedback during first installations.
Supplier Management	Early close coordination with engineering, participation in drawing release reviews	Strong participation. Provided part-by-part status weekly. Aggressive resolution of issues.
Support Systems	Development of own performance metrics and reporting progress to stakeholders	Enthusiastic participation in design reviews. Early coordination of validation impacts with customer.
Training	Early coordination with engineering aided course development	Early development of plan, communication with project team and customer
Field Services	Early visibility from design reviews. Aided planning of future customer support	Initiative in learning the system prior to first delivery
Flight Test	Full time interaction with design team, from development through test flights	Outstanding management of installation of instrumentation in production. Close coordination with engineering when developing test plans.
Pilots	Dramatic potential improvement of inerting system	Affirmation during base visits
Maintainers	Design reviews at bases prior to implementation. Participation in mockup installation.	Enthusiastic participation at bases during reviews, mockup installation, follow-up communication
Customer Engineering	Involvement in project selection. Frequent, regular communication. Full system lab test.	Strong support for project. Teamwork in decisions addressing challenges, regular communication.
Suppliers	Frequent communication, design reviews,– they were team members	Strong participation in developing design solutions. Commitment to schedule needs.

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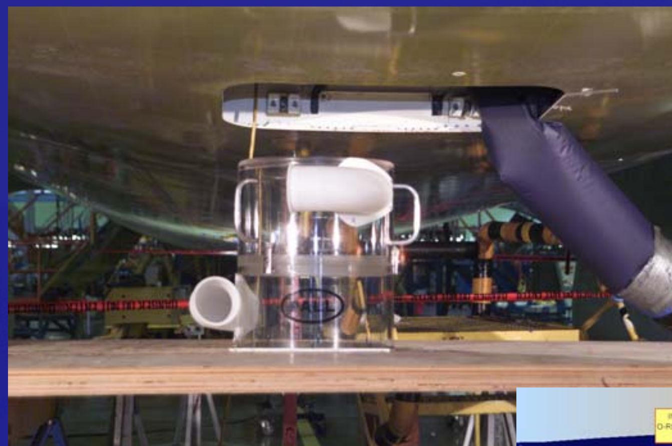
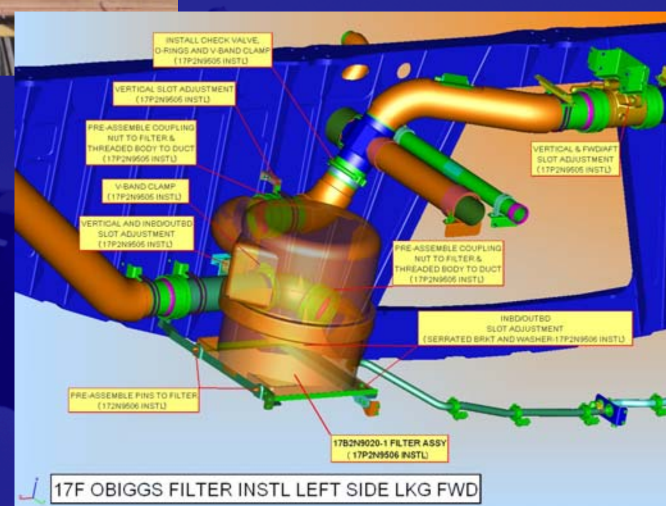
How Stakeholder Buy-in Was Ensured

OBIGGS II





Stakeholder participation in design development

BOEING

OBIGGS II

How Various Types of Resistance Were Identified and Addressed

Type	How Identified	How Addressed
Customer reluctance to fund project due to high cost	Customer feedback during negotiations	Detailed estimates, competitive pricing & life cycle cost analysis
Supplier not willing to control interfaces to requested tolerances	Interface Key Characteristic reviews	Negotiated compromise during weekly supplier coordination meetings
Production schedule impact from late parts	Feedback from production stakeholder on team	Established agreed-to lead times for parts
Production schedule impact from learning curve	Feedback from production stakeholder on team	Fit checks, dedicated engineering support
Production concern about part damage on installation	Feedback from production stakeholder on team	Assembly simulation and created protective covers
Cluttered production work space	Lean initiatives coordination meetings with Production	Created point-of-use carts to transport selected parts
Flight test airplane out of service too long	Customer feedback during flight test planning	Installed instrumentation in production
Resistance to Model Based Definition from QA	QA feedback at first article inspection	Generated 2D inspection sheets from 3D models

How Various Types of Resistance Were Identified and Addressed

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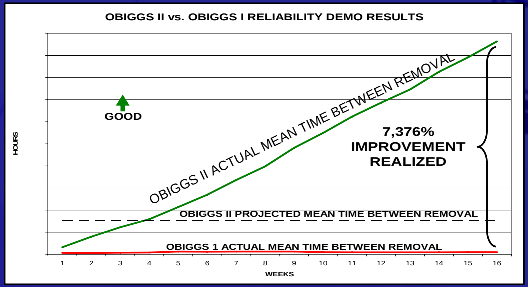
Types of Tangible and Intangible Results That Were Realized

Tangible Benefits



Achieved 7400% Increase in system reliability vs. 1100%

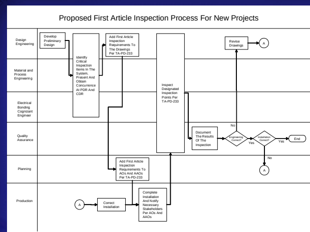
Reduced Initialization Time by a factor of 11 vs. 5

Reduced weight by 517 lbs. vs. 475 lbs. allowing for increased cargo capability

20% system and 3:1 life cycle cost savings as predicted

How Results Link with Organization Goals, Performance Measures and Strategies

OBIGGS II



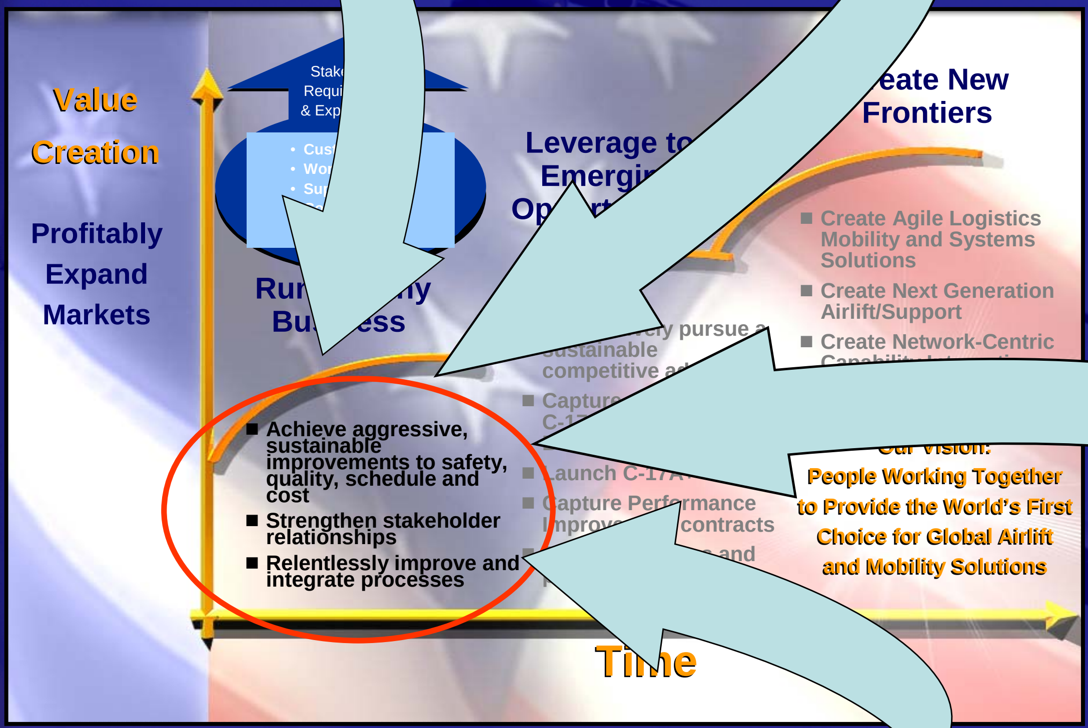
Process Improvements

- Four different processes

Reduced Initialization Time

- Improved by a factor of 11


(US Air Force Photo)



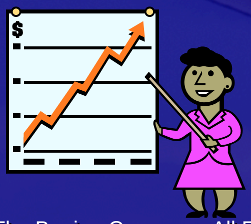

(US Air Force Photo)

Improved Reliability

- Improved by a factor of 74

Increased Revenue

- Captured excellent rating for every award fee period throughout the project



BOEING

OBIGGS II

Thank You!

Mission Accomplished!

(US Air Force Photo)

The Joint Partnership between Program Management & Systems Engineering on Support System Program

Samuel Son

and

Mark Keller

Topics of Discussion

- Overview
- The Partnership Umbrella
  - Program Management (PM)
  - Systems Engineering (SE)
  - Interrelationships Between PM and SE
- Systems Engineering Process Stabilization & Enhancement
  - Contractor Performance Assessment Reporting (CPAR) Review
  - Project Performance Assessment & Review Process
  - Program Management Best Practices (PMBP)
  - Systems Engineering Best Practices (SEBP)
- Users of the Systems Engineering Process at Multiple Organization Levels
- Total System Support Responsibility (TSSR)
- Conclusion

Overview

Support System Program

- Provide warfighter sustainment that guarantees readiness, aircraft availability, and affordability

Program Management

- Management of key program items, such as costs, timely delivery, people, quality, and risks

Systems Engineering

- Ensures common application of Systems Engineering processes, implementation, and execution to facilitate program and mission success

Program Management and Systems Engineering, along with government and industry best practices, become interdependent to successfully monitor, measure, manage and execute Support System Integration activities

= Warfighter Sustainment

Topics of Discussion

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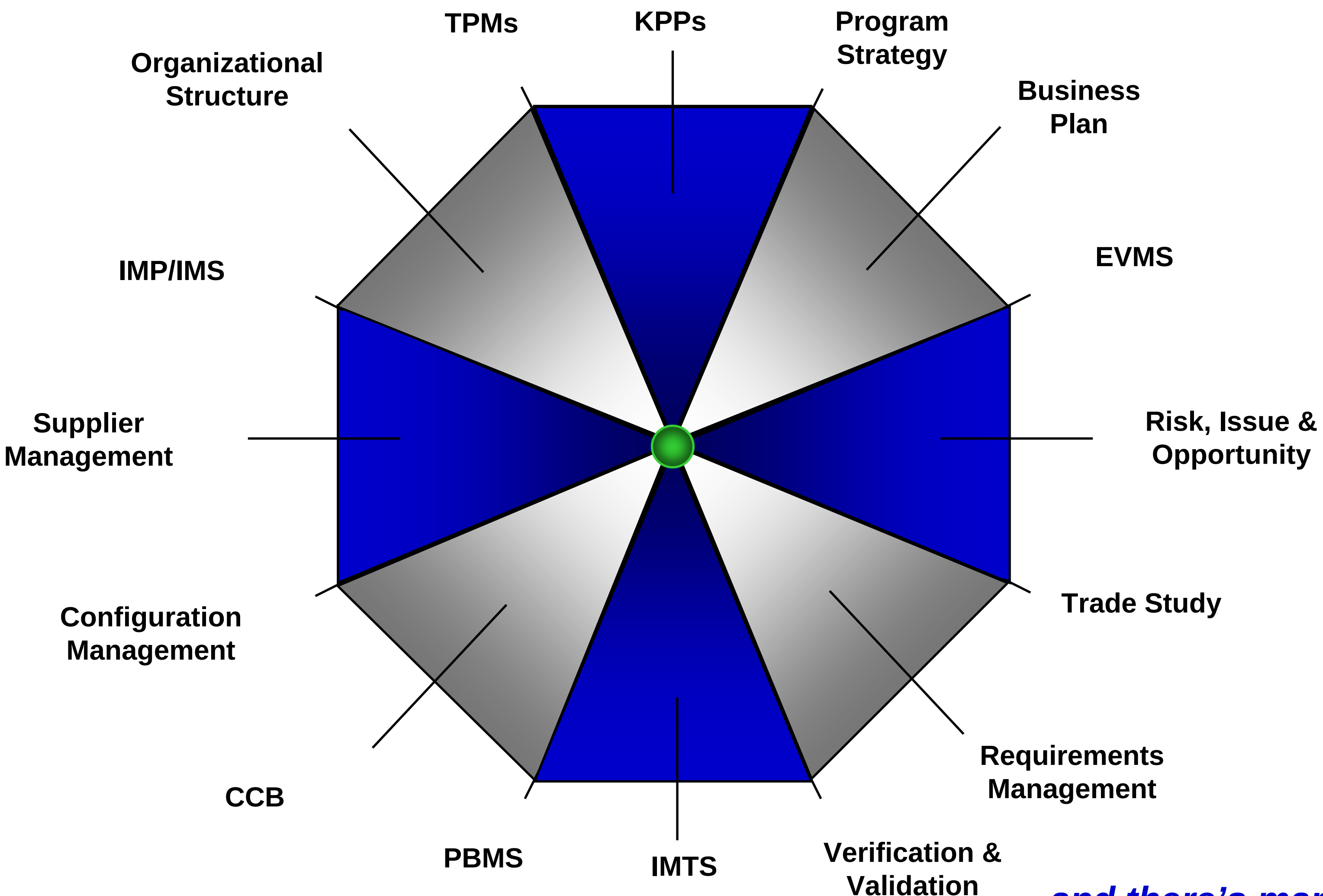
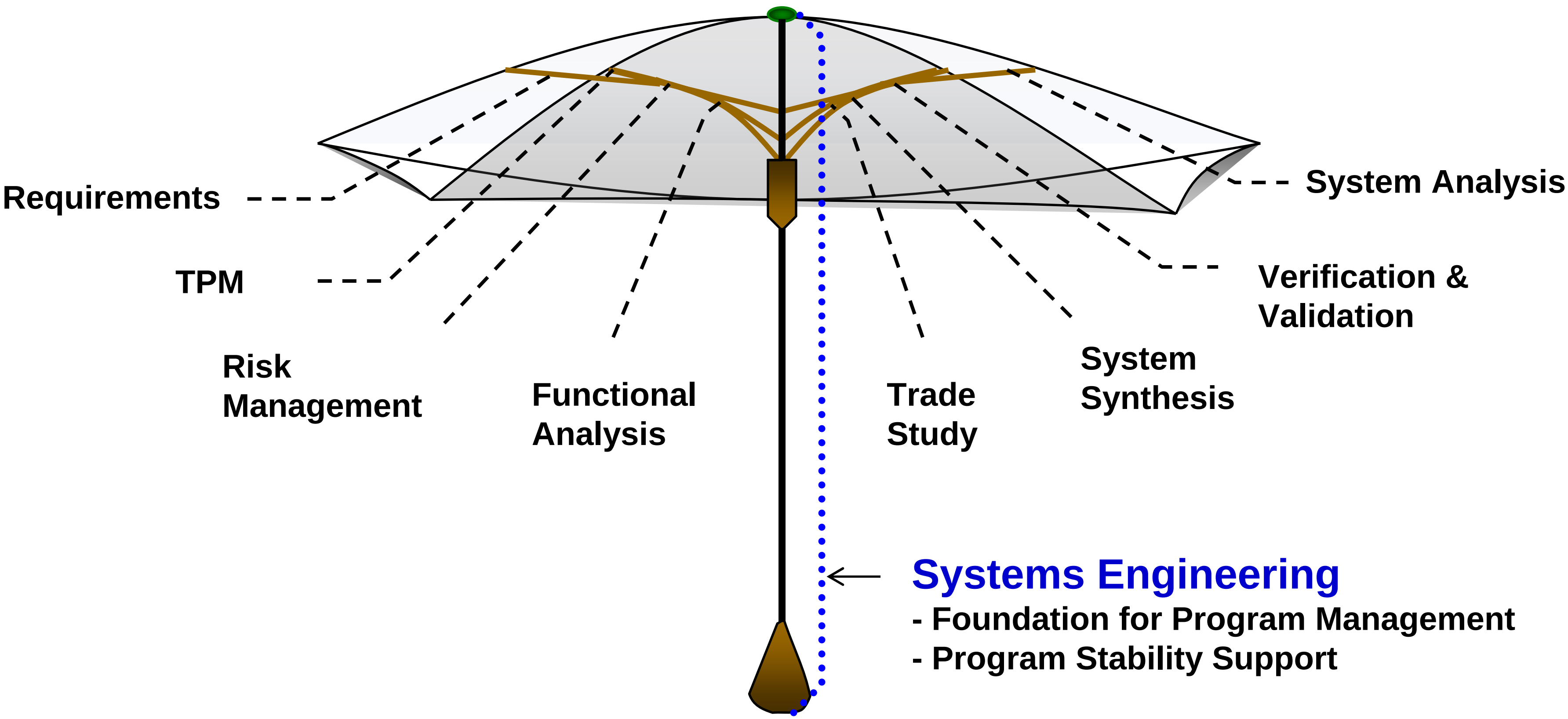
The Partnership Umbrella: Program Management

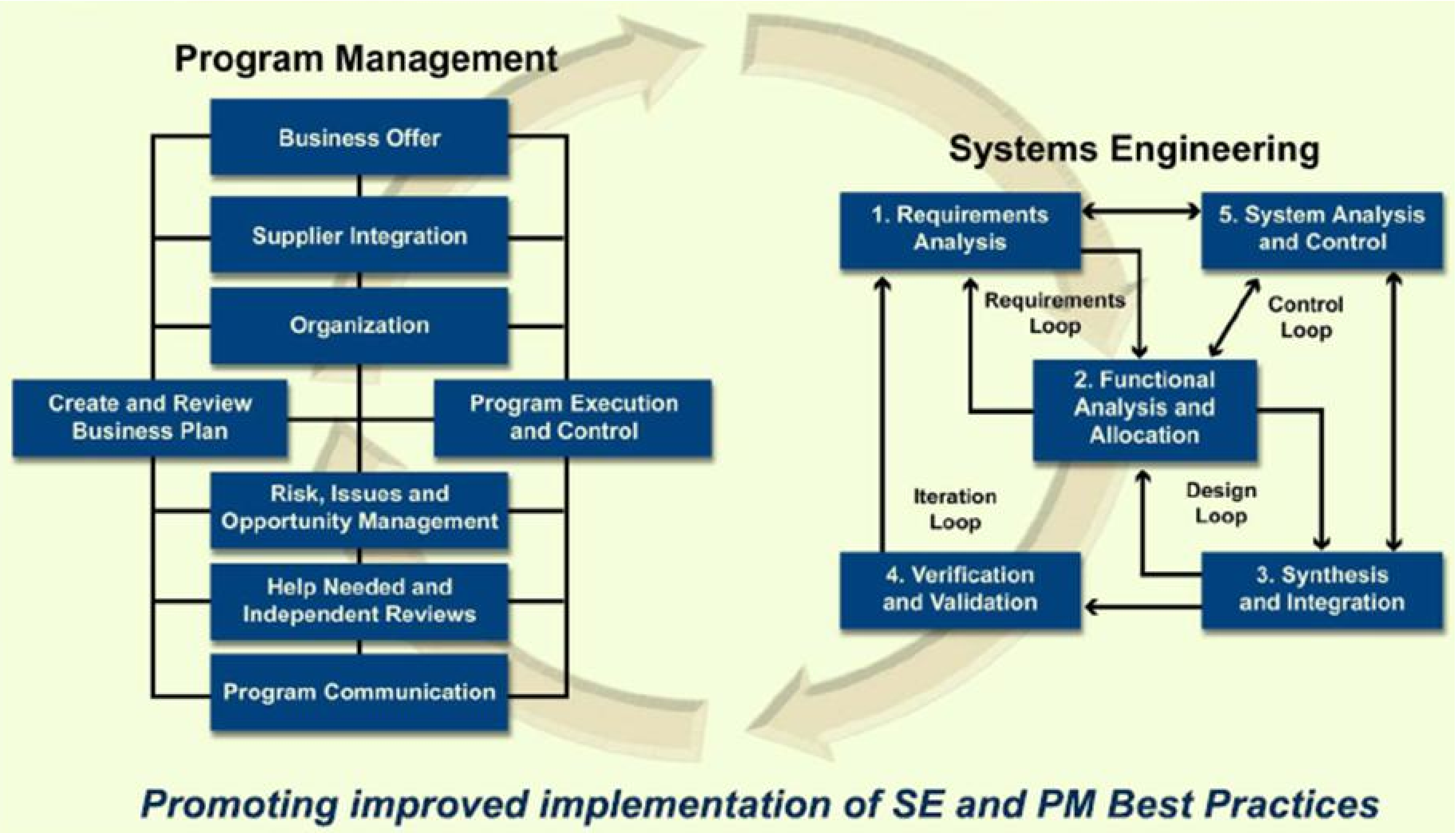


…and there's many more.

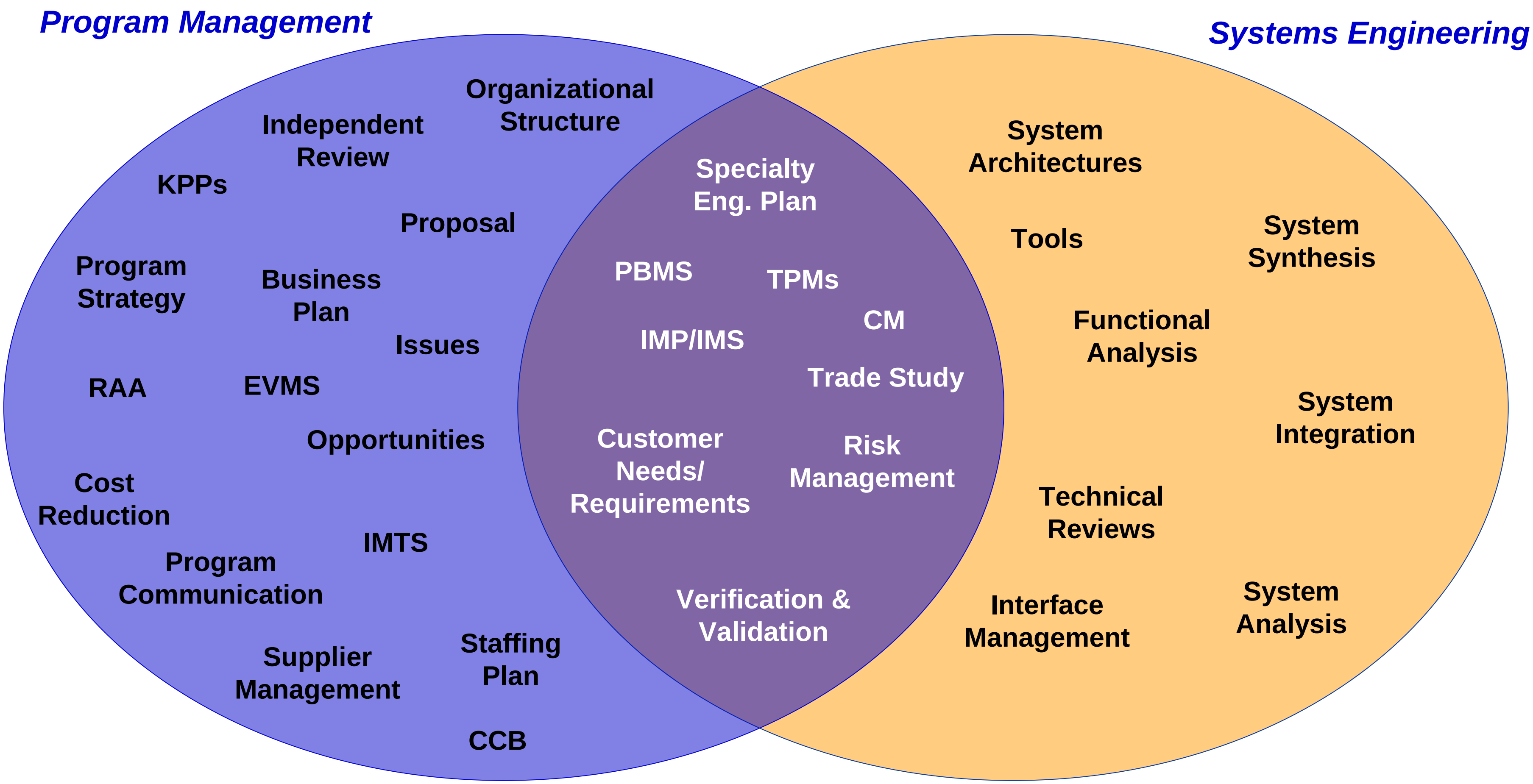
The Partnership Umbrella: Systems Engineering



The Partnership Umbrella: Interrelationships



The Partnership Umbrella: Interrelationships



Topics of Discussion

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- **Systems Engineering Process Stabilization & Enhancement**
  - Contractor Performance Assessment Reporting (CPAR) Review
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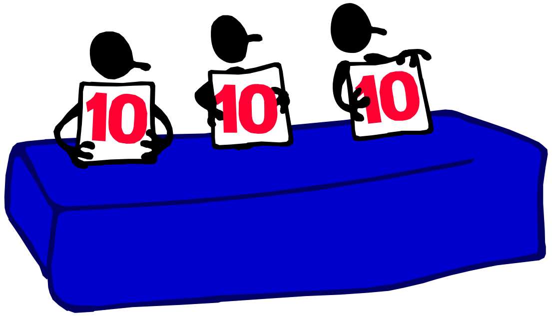
SE Process Stabilization & Enhancement (examples)

- Systems Engineering Supporting Program Management
  - Provide Systems Engineering Processes
  - Perform Assessments & Best Practices
    - Contractor Performance Assessment Reporting (CPAR) Review
    - Project Performance Assessment & Review Process
    - Program Management Best Practices (PMBP)
    - Systems Engineering Best Practices (SEBP)

- Assessments & Best Practices provide total visibility on strengths and weaknesses in Systems Engineering as well as progress of improvement efforts



Contractor Performance Assessment Reporting (CPAR)

- Objectives:
  - Ensure that accurate data on contractor performance is current and available for use in source selections
  - Consistently provide quality, on-time products and services that conform to contractual requirements
  - Effectively communicate contractor strengths and weaknesses to source selection officials

- Systems Engineering Supporting Program Management:
  - Use Award Fee Rating Criteria
  - Review Customer's AFAST Database
  - Review Award Fee Review Charts
  - Review Project Integration Weekly Reports
  - Field Service Weekly Reports

Project Performance Assessment and Review Process

- Objectives:
  - To rate, assess, and report project performance to management and the customer

- Systems Engineering Supporting Program Management:
  - Review Technical Performance Measurement
  - Review Systems Engineering Compliance
    - Requirements, Risk, Verification, Formal Review, and Critical Action Item(s)

- Support Systems Supporting Program management:
  - Review Support Systems
    - Tech Orders, Support Equipment, Spares, and Repair of Repairable
  - Review Trainings
    - Maintenance ‘Type-1’ Training
    - Retro Training

Program Management Best Practices (PMBP)

- Objectives:
  - To achieve successful program development, implementation and support based on an integrated set of Program Management Best Practices

- Systems Engineering Supporting Program Management:
  - Review maturity level for program execution & control
  - Use program execution & control best practice criteria
    - Allocation and traceability of program requirements
    - Identification of Program-level KPPs
    - Allocation and traceability of TPMs

Business Proposition	***Business Plan***	***Program Execution & Control***	***Organization***
Program Communication	***Supplier Integration***	***Risk, Issue & Opportunities***	***Help Needed & Independent Review***

Systems Engineering Best Practices (SEBP)

- Objectives:
  - Strengthen Systems Engineering
  - Maintain the Capability Maturity Model Integration (CMMI) Level 5

- Systems Engineering Supporting Program Management
  - Develop Systems Engineering Best Practices Self Assessment Plan
  - Review overall attributes associated with each of the Best Practices
  - Develop Systems Engineering Management Plan to include the Support System
  - Improve training materials
    - Requirements Management
    - Risk Management
    - Technical Performance Measures
    - Trade Studies
    - Verification & Validation
  - Provide Systems Engineering training to Project Managers

Topics of Discussion

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Users of the SE Process at Multiple Organization Levels

S E A L I G N M E N T

Enterprise Level

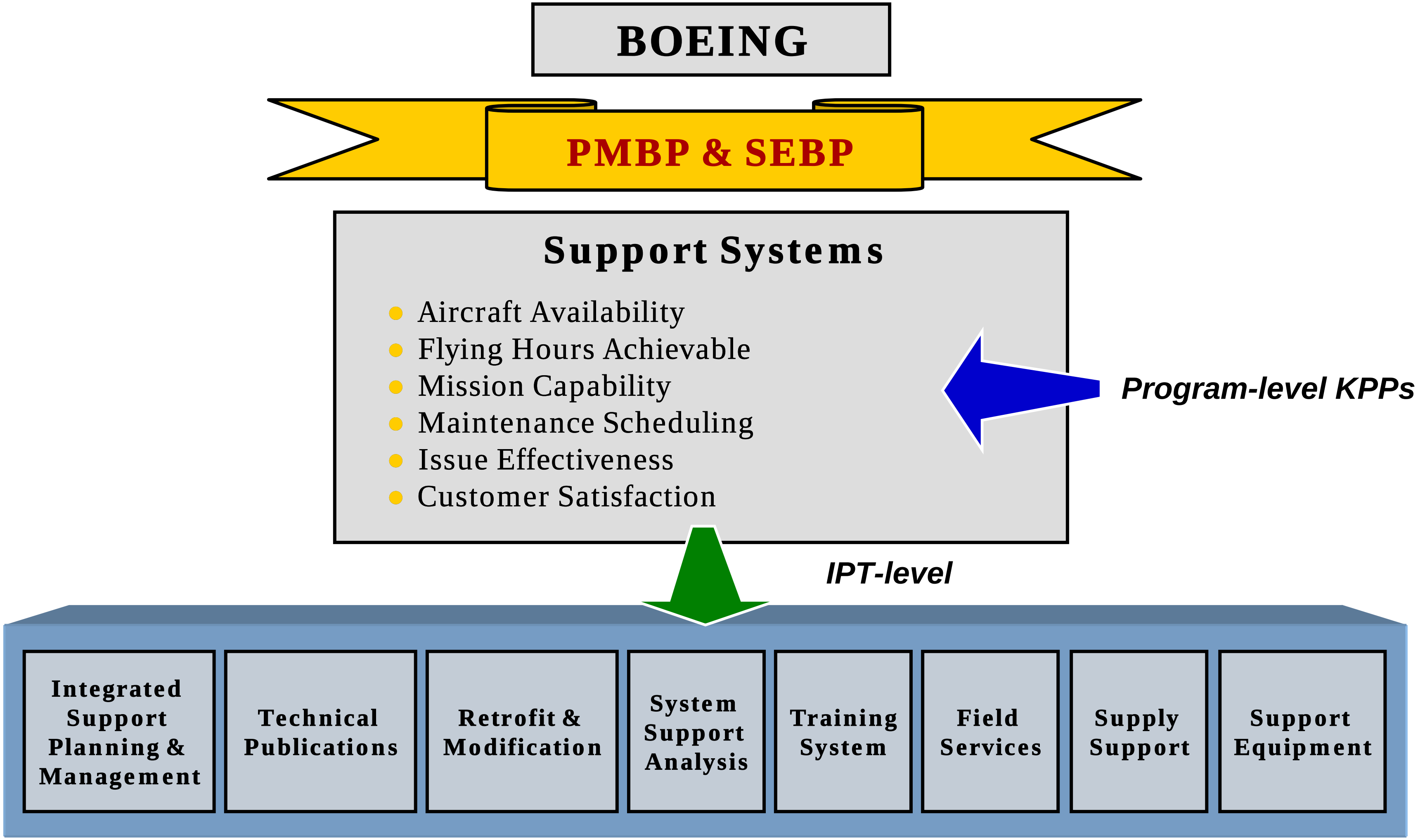
Program Level

Integrated Product Team Level

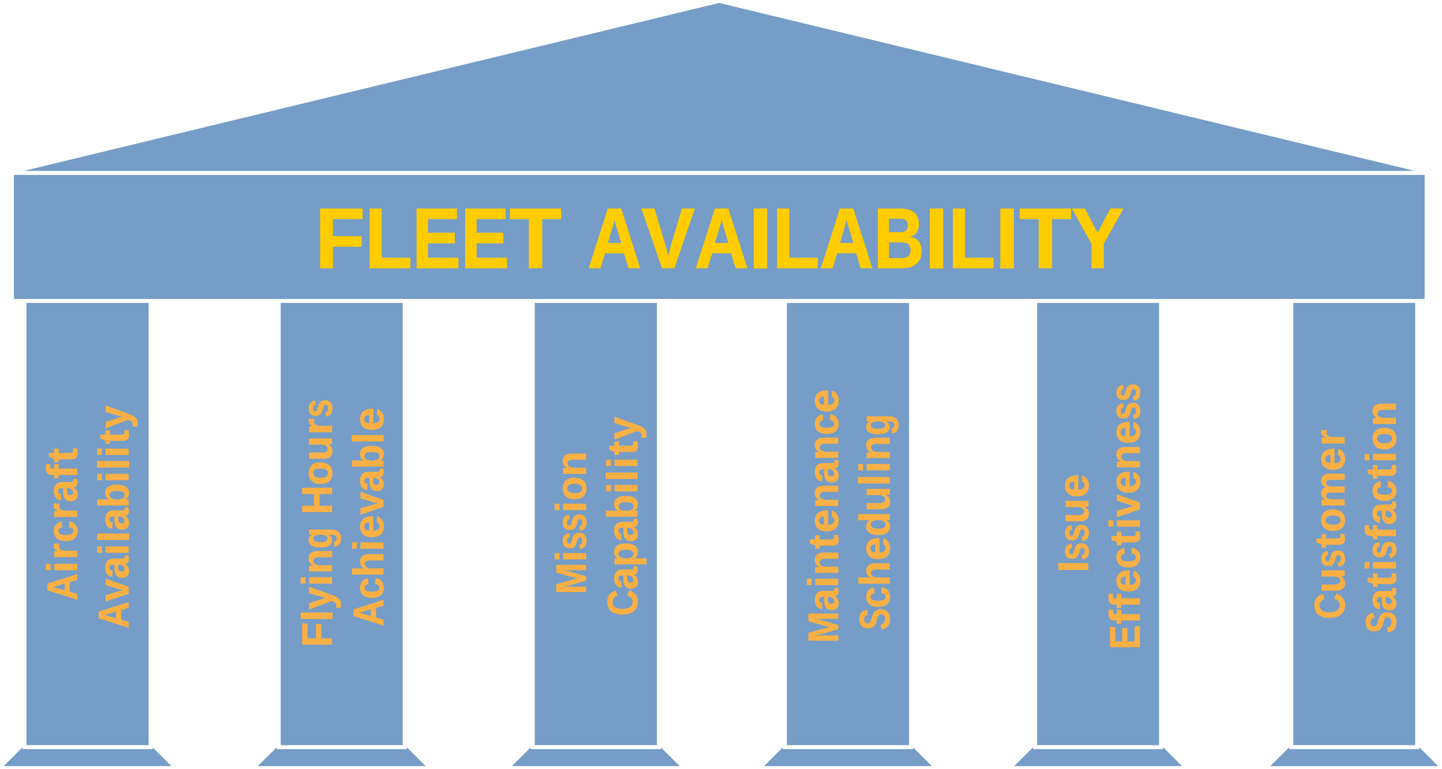
Project Level

Image Source: University of Toronto Magazine

PMBP & SEBP at Multiple Organization Levels



Six Program-level KPPs for Support Systems



AIRCRAFT AVAILABILITY AND CUSTOMER SATISFACTION ARE PARAMOUNT

Support Systems – Integrated Product Teams

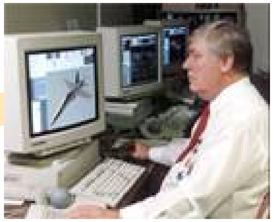
Supply Support

Field Services

Training Systems

Integrated Support Planning & Management

Technical Publications



Retrofit & Modification

System Support Analysis

Support Equipment

Customer Satisfaction

Topics of Discussion

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Total System Support Responsibility (TSSR)

- What is TSSR?:
  - A program built on the performance-based approach that uses the combination of best of **government** and **industry** practices to provide **support program affordability** and **improved aircraft availability**

- Benefits:
  - Provides the customer with an **affordable** and **optimum sustainment solution**: as single source that guarantees support, readiness, **availability**, **24/7 customer service**, and equates to a more **efficient**, **effective**, and **consistent support program**
  - Ability to move technical **data** into the **field faster**
  - **Directing maintenance** to each individual aircraft's **weaknesses** before **malfunctions occur**
  - Balances heavy maintenance workload and **ensures reserve capacity**

Total System Support Responsibility (TSSR) Cont’

- ***Keep services affordable***
- ***Increase fleet availability***
- ***Reduce cycle time***

Customer Satisfaction

Topics of Discussion

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Conclusion

- The synergistic partnership between Program Management and Systems Engineering on Support System Program is an essential enabler:
  - To keep services affordable
  - To increase fleet availability
  - To improve effectiveness and reduce cycle time

- Benefits to the weapon system
  - More responsive to mission demands
  - Higher quality services & products
  - On time deliveries – reduced depot time
  - Increased weapon system availability

Conclusion

- Benefits to the Customer
  - Reduced cycle times
  - Easier to execute purchasing arrangements
  - Fewer transaction
  - Lower support costs

- Benefits to suppliers
  - More predictable, longer term business
  - Strategic, focused relationships
  - Fewer, higher-value contracts
  - Lower overhead costs

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Thank you!

Questions? | **We might have answers…**

NORTHROP GRUMMAN
DEFINING THE FUTURE

A Day in the Life of a Verification Requirement

Systems Engineering Conference
National Defense Industries Association

Oct. 22-25, 2007

Stephen Scukanec
Test and Evaluation

James van Gaasbeek
Requirements Development, Management and Verification
Northrop Grumman Corporation

Approved for Public Release, Control No. 07-097, dtd. 10-3-07

Agenda

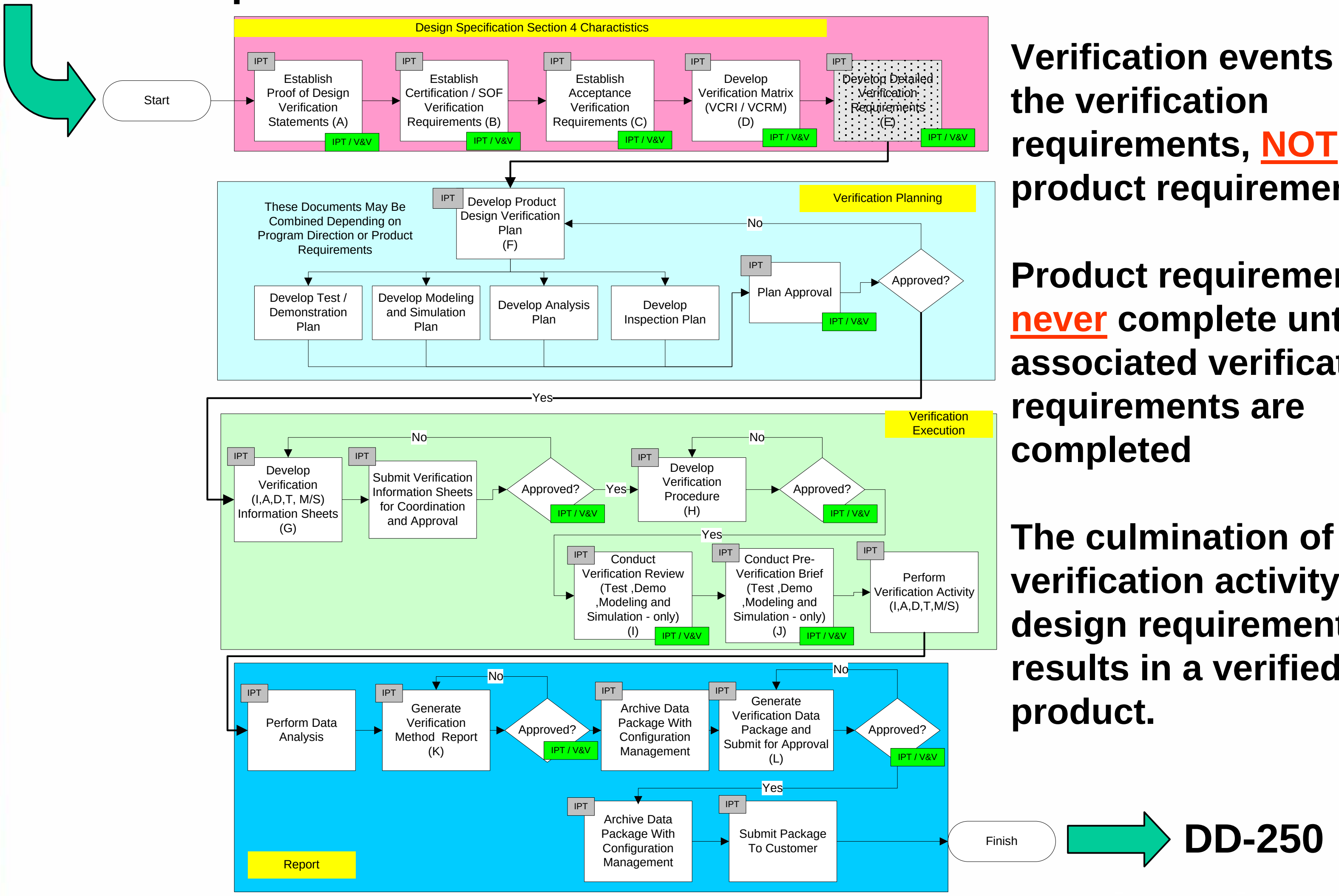
- Why Verification
- Overall Process
- Verification Cross-Reference Matrix
- Verification Attributes
- Requirement Samples
- Verification Plans
- Benefits
- Summary / Conclusions
- Abstract
- Author Biographies

Verification Requirements – What Are They And Why Do We Need Them?

- Verification requirements specify the verification events needed to prove the satisfaction of the product requirements and help to define the verification process and environment
- Verification requirements are necessary for at least two reasons:
  - Existence of verification requirements demonstrates verifiability of product requirements
  - Agreed-to verification requirements define the verification program by which the contractor shows that the product is what the customer needed

A Day in the Life of a Verification Requirement

Product Requirements



Verification events satisfy the verification requirements, NOT the product requirements.

Product requirements are never complete until the associated verification requirements are completed

The culmination of the verification activity of the design requirements results in a verified product.

NDIA SED Conference, Wednesday, 24 October 2007, Track 1, Paper 5536
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Start with Product Requirements

- The verification process begins with authenticated product requirements
- Examples
  - PR-1:LRU markings
    - The product line-replaceable units shall be marked in accordance with MIL-STD-130M.
  - Pr-2: operational availability
    - The product shall have an operational availability (A_0) of 97.5% at IOC.
  - Pr-3: lru accessibility
    - Each product line-replaceable unit shall be able to be removed and replaced without removing any other item or displacing any cables.
  - Pr-4:recovery force communication - nominal
    - The product shall provide a communications system capable of communicating with the ground command.

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Create Verification Cross-Reference Matrix

Design Requirement

3.2.2.15.34 Recovery Force Communications
The communications system shall provide a communications system capable of communicating with the recovery forces pre- and post- landing

SE – Translates Operational Objectives into Design Requirements

Design – Provides assessment of requirements implementation

Test – Provides assessment of requirements verifiability

Design Verification

Verification Objective	Pass / Fail (Success Criteria)
Perform Integrated System Test of the communications system capability to provide a voice communications and beacon with recovery forces pre and post landing within an integrated hardware / software environment	Testing will show that the communications system can transmit and receive audio at frequencies and ranges (power) represented by standard ground recovery force communications devices as defined in TBD
Perform a demonstration of the communications systems capability to provide voice and beacon communications with recovery forces pre and post landing while within a representative environment and using a production equipment configuration	Testing will show the ability for the communications systems to verbally communicate with the on board communication production configuration equipment. The demonstration will also show beacon tracking within communication ranges established by TBD.

<u>SE</u> – Provides compliance of the design requirement

<u>Test / Implementation Group</u> –

Ensures Verification Implementation Feasibility

Advises alternatives to support programmatics

Assess completeness

Provides verifiability assessment

Traceability

Verification Cross Reference Matrix

Paragraph #	N/A	I	A	M/S	D	T
3.2.2.15.34						T3
3.2.2.15.34						T5

SE – Verification Allocation and Traceability Assurance

Identifying a verification method is necessary, but not <u>sufficient</u>!

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Verification Requirement Attributes

Verification Requirements
•Inspection
•Analysis
•Modeling and Simulation
•Demonstration
•Test

Must answer 5 Questions

☑Objective

What is the purpose of this verification?

☑Method

What method do you need performed? What are the verification circumstances (e.g., laboratory, desk-top analysis, flight test)?

☑Environment

What are the environmental conditions under which the item will be verified?

☑Special Conditions (if necessary)

Are there any unique conditions (e.g., item configurations) necessary for the execution of the verification?

☑Success Criteria

What results are to expected?

Verification isn't <u>ONLY</u> test!

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Sample Verification Requirements - 1

- **VR-1l: compliance of product markings shall be verified by examination of design drawings at the LRU supplier's location prior to the LRU CDR. The inspection will show that each marking on the LRU conforms to MIL-STD-130M.**
- **Vr-2a: the product operational availability shall be calculated using the results of the government-accredited contractor-developed reliability and maintainability analyses performed during the design in conjunction with the design reference missions documented in report xxxx. The analysis will show that the product, in its operational environment, supported with its support equipment and personnel, across all missions, will have an operational availability of at least 97.5%.**

Sample Verification Requirements - 2

- **VR-3D: Removal and replacement of all lrus shall be demonstrated on the aircraft to show that each LRU can be removed and replaced without removing any other items or moving any cables.**
- **Vr-4d: Perform demonstration to provide a communications system capable of communicating with the ground command team while in a representative environment and production configuration. Demonstration will show capability to communicate with recovery forces at TBD distances in the TBD terrain environment.**

Sample Verification Requirements - 3

- **VR-4T: Prove that the product's communications system is capable of communicating with the ground command team by performing an integrated system test within an integrated hardware/software environment. Testing will show that the product can transmit and receive audio at frequencies represented by standard ground recovery forces communications devices defined in (TBD).**

Verification Objective

Verification Method

Environment

Success Criteria

Note – there are no Special Conditions

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Verification Requirements Flow and Traceability

PR-1	PR-2	PR-4	PR-5
VR-1I	VR-2A	VR-4D	VR-5T

Specification

Design Requirements

Verification Requirements

Verification Requirements Appear in the Same Specification as the Product Requirements to be Verified

Product Requirement	N/A	Insp	Analy	M&S	Demo	Test	Verification Requirement
PR-1		X					VR-1I
PR-2			X				VR-2A
PR-3				X			VR-3MS
PR-4					X		VR-4D
PR-5					X	X	VR-5D VR-5T

Master Verification Plan

Inspection **VR-1I**
Analysis **VR-2A**
Modeling and Simulation
Demonstration
VR-3D, VR-4D
Test
VR-4T

Verification Requirements

Verification Traceability

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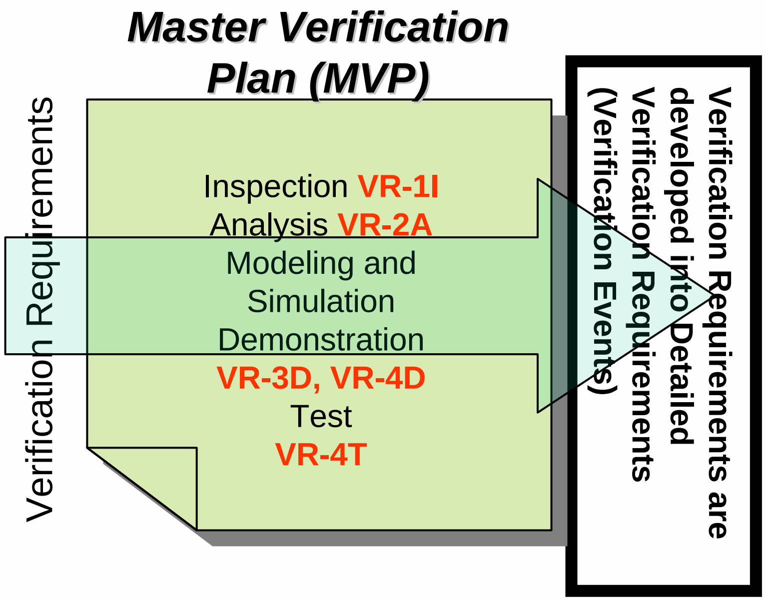
Create Detailed Verification Requirements (Verification Events)



A One To One Relationship Exists Between the Verification Requirements and the DVRs

Convert verification statements into detailed verification requirements (verification events) by ----

For each verification activity identified in the verification matrix, a detailed description of the activity including:

- **Verification configuration & its relationship to production configuration**
- **Associated prerequisites**
- **Constraints**
- **Objectives**
- **Procedures**
- **Relevant environmental conditions**
- **Pass/fail criteria- and necessary Data Set,**
- **Analysis models, if applicable.**
- **Sequence if applicable**
- **Verification Environment (i.e.; Lab, Flight, Production)**

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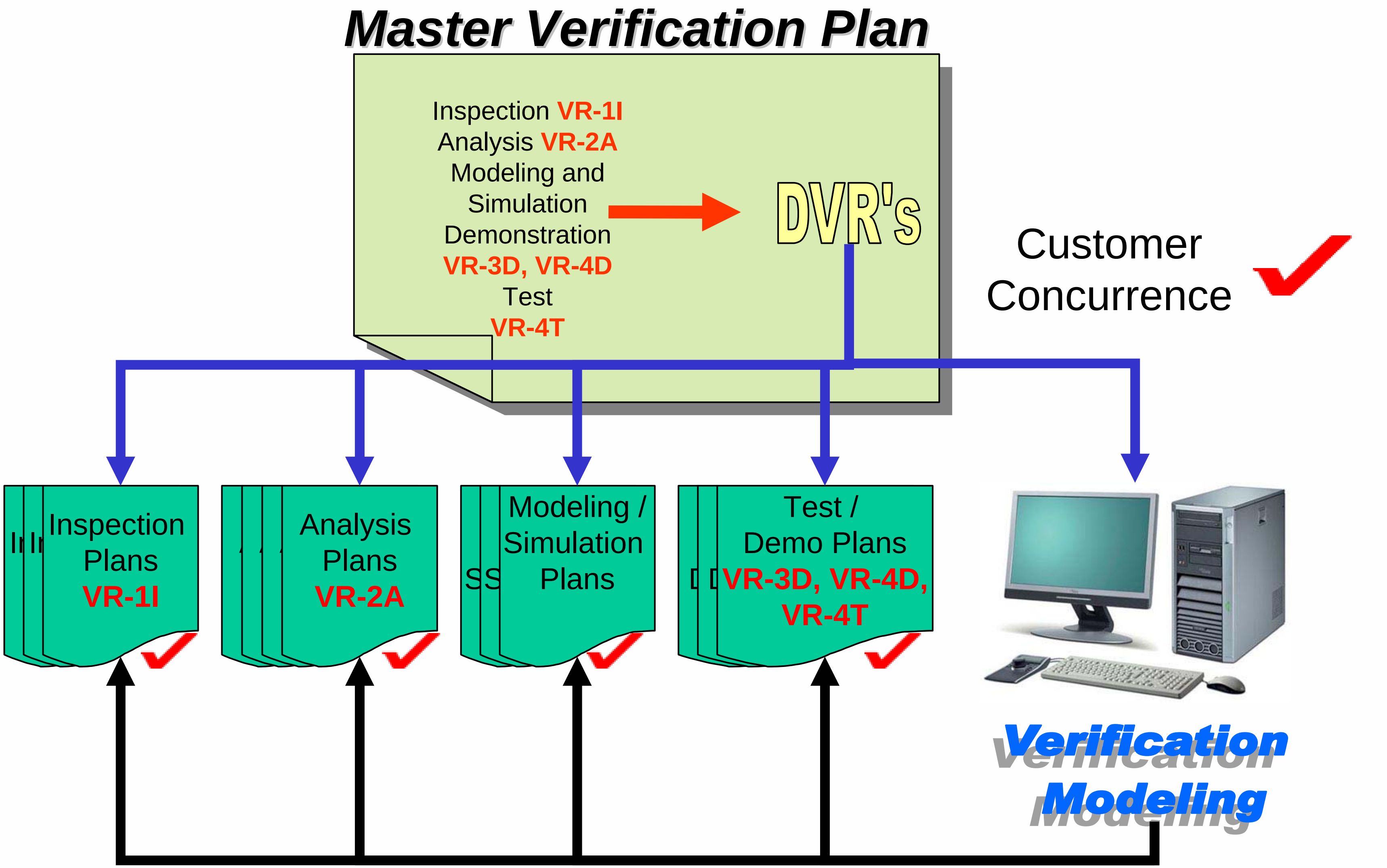
Master Verification Plan



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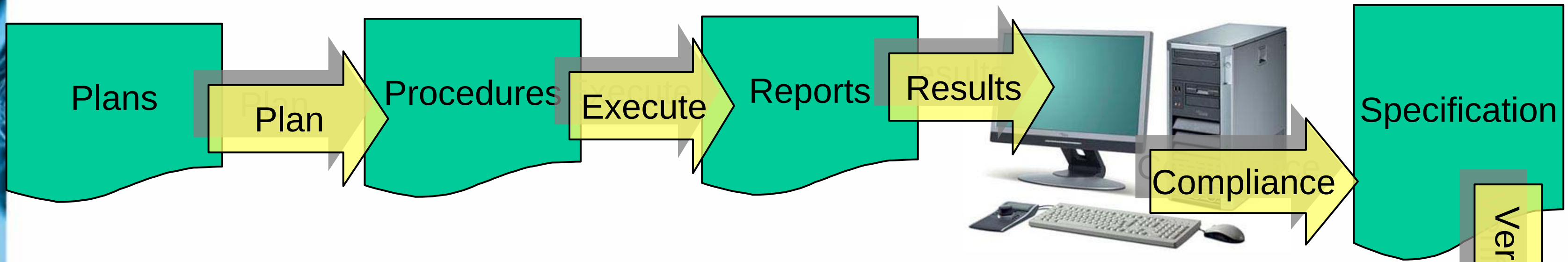
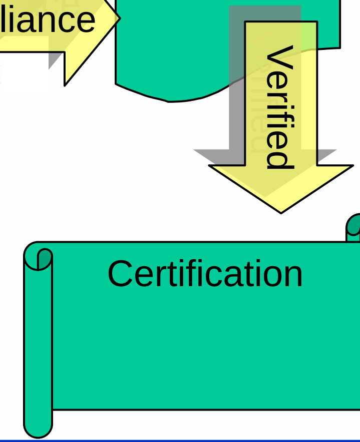
NORTHROP GRUMMAN

Verification Execution Flow





Method	Organization	Early Verification Benefits
Inspection	QA, Manufacturing, Mission Assurance	▪Inspection Points Identified ▪Tooling Requirements Identified
Analysis	Systems Engineering Specialty Engineering Design	▪Define / Build / Buy / Train Analysis Prior to Need Date ▪Accreditation of Analyses Tools Prior to Need Date
Modeling and Simulation	Systems Engineering Specialty Engineering Design, Operational Assessment	▪Define / Build / Buy / Train Modeling and Simulation Tools Prior to Need Date ▪Accreditation of Models Prior to Need Date
Demo & Test	Ground and Flight Test Facilities Development	▪Laboratory and Lab Software Requirements Identified ▪Facilities Requirements Identified ▪Long Lead Test Items Identified

Early Verification Supports Multiple Organizational Functions' Long Lead Needs and Prevents Costly Late Program Re-Work

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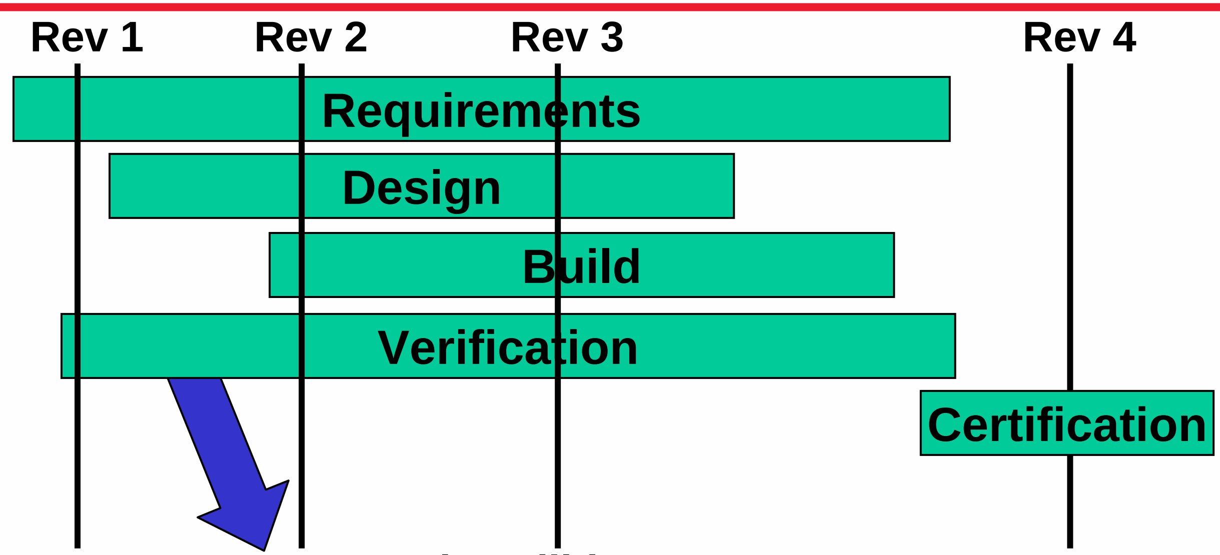
Planning for Verification Execution and Product Verification



Define Verification Requirements Early and in Detail to Establish the Entire Verification Effort

Long Lead Facilities
Laboratory Design
Range Coordination
Design Requirements
Software
Analysis Tools

Discover the Verification Requirements Late and Have Enormous Rework to Establish the Entire Verification Effort

… and it Costs Relatively little …

… and it Costs a Lot More …

Early Verification Is an Effective Cost Avoidance Approach

NORTHROP GRUMMAN

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Summary and Conclusions

- The verification process begins with authenticated product requirements
- Define verification requirements, not just methods – the VCRI is the last thing developed in the specification
- Verification requirements must state the objective, method, environment, and expected results. There may also be special conditions.
- The master verification plan is the guidance for the verification program
- Verification is conducted against the product defined by the title of the specification
- Verification program benefits are not limited to just the systems engineering and test organizations
- Define the verification requirements early to reduce the overall program cost

Abstract

- One measure of the quality of a product requirement is that it be verifiable. Verifiability assessment is one of the exit criteria for the Systems Requirements Review and is necessary for requirement validity. Nomination of one or more verification methods (inspection, analysis, modeling and simulation, demonstration or test) is often taken as the sole evidence of verifiability. A completed Verification Cross Reference Matrix is frequently considered as the final verifiability assessment and responsibility for the remainder of the verification effort is transferred to the test and evaluation and other implementing communities for completion.
- Lessons learned from many Programs have shown that a more robust application of systems engineering should include the requirements engineers (with detailed knowledge of product requirement intent) working with the implementing organizations as the best combination to define the verification requirements. Such definition should include statement of the verification objectives, success criteria and environment. Including this information in the "Quality Assurance" section of the requirements document allows for buy-in by the customer well in advance of implementing the verification activities. This information is used by verification personnel to generate one or more verification plans and to develop the detailed verification program. Verification requirements are planned into verification events which are executed using the proper system elements and environments. These verification requirements are key to establishing long lead verification facilities, tools and laboratories. Early definition of these requirements helps prevent facility re-designs and verification re-plans that can cause expensive delays. Finally, verification data analysis is performed, and the information compiled into verification reports certifying system product requirements compliance. This robust verification approach will provide proof of requirements satisfaction, leading to systems that meet the customers' needs at a lower life-cycle cost.
- This paper describes these concepts and steps in detail and provides examples for a set of generic aircraft requirements.

Author Biographies

- Steve Scukanec has spent over 25 years as an Aerospace Engineer on various complex programs including the B-2, B-2 Long Term Software Support, F-35. With a focus on test and evaluation, Steve has been able to participate in programs from inception to completion. This experience over several programs has provided Steve with a rare understanding of the values of a well executed Verification program as well as the problems caused by the lack of one. His experience as a “requirements generator”, “requirements customer”, “requirements manager” and verifier gives him insight into the lifecycle of a requirement and a large lessons learned knowledge base.
- Jim van Gaasbeek has 35 years experience analyzing and developing rotary-wing and fixed-wing aircraft, launch vehicles and spacecraft, both in the United States and European defense environments. Beginning as a rotor aeroservoelastician, his career has progressed with experience in constructive and virtual simulation, accident investigation, vehicle-management system design and systems engineering, concentrating in risk management and requirements development, management and verification.

Advancing the Federation Development and Execution Process (FEDEP) for Simulation Based Acquisition (SBA)

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Paul Lowe
IS&T SPDT Deputy Chief Software Engineer
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Introduction

- Simulation Based Acquisition (SBA) programs are confronted with two paradigms that compete for program level focus and resources.
  - The first paradigm requires modeling & simulation (M&S) teams to develop simulation environments for testing in order to “sell-off” the SBA program. This line of thought invariably demands immediate attention toward developing unique simulation based event configurations for supporting intermediate tests, experiments and capability demonstrations.
  - The second paradigm requires the same M&S teams to concurrently develop a robust collection of simulation environment tools for SBA contract delivery.
- A proposed tailoring of the Federation Development and Execution Process (FEDEP) is set forth, capturing the maturation of requirements within a Spiral Lifecycle Model (SLM), allowing these two paradigms to co-exist over the lifecycle of a development program, making the SBA process more effective.

Goals and Process

- Goals
  - Identify alignment of FEDEP with program systems engineering processes
  - Fill gaps to create robust federation engineering process
  - Share lessons learned with other large SBA programs
- Process
  - Bottom-up mapping of FEDEP artifacts to existing program artifacts
    - Look for gaps in federation artifacts to improve FCS process
  - Top-down mapping of planning conferences through anchor points to FEDEP steps/activities/tasks
    - Identify how information and artifacts must flow from the customer through the systems engineering processes into the final federation artifacts
    - While anchor points are not used by many programs, the concept and process for performing this mapping are broadly applicable
  - Identify opportunities for reuse of artifacts from IP to IP, minimizing rework
    - Applicable to any large, iterative SBA program
  - Make recommendations for additions/modifications to program processes and artifacts
    - While some of these lessons learned are specific to FCS, many are broadly applicable

Processes to Be Aligned

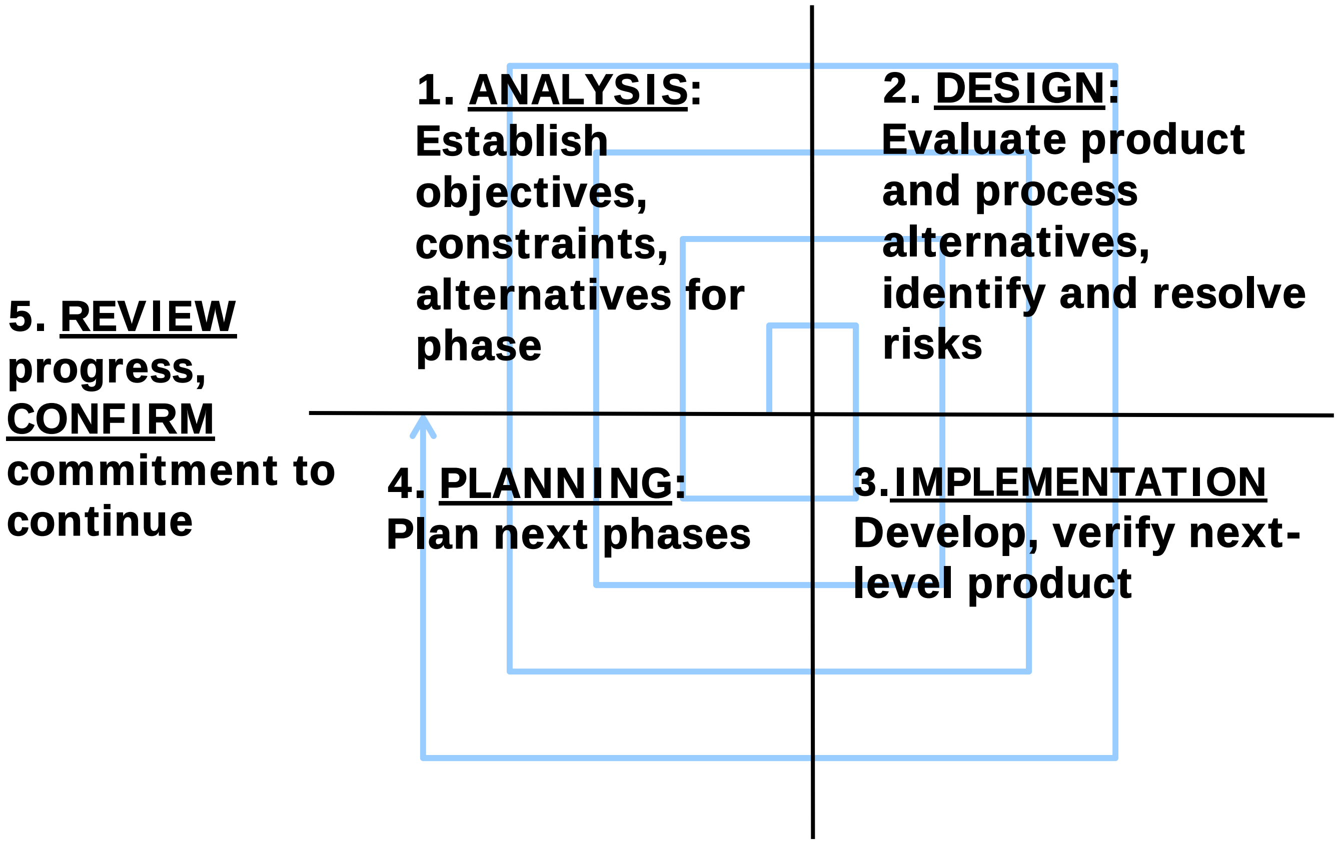
- Planning conferences
- System of systems (SoS) spiral lifecycle model (SLM) anchor points (APs)
- Federation Development and Execution Process (FEDEP)

Army M&S Specific Guidance for Planning Conferences

IPC	MPC	FPC

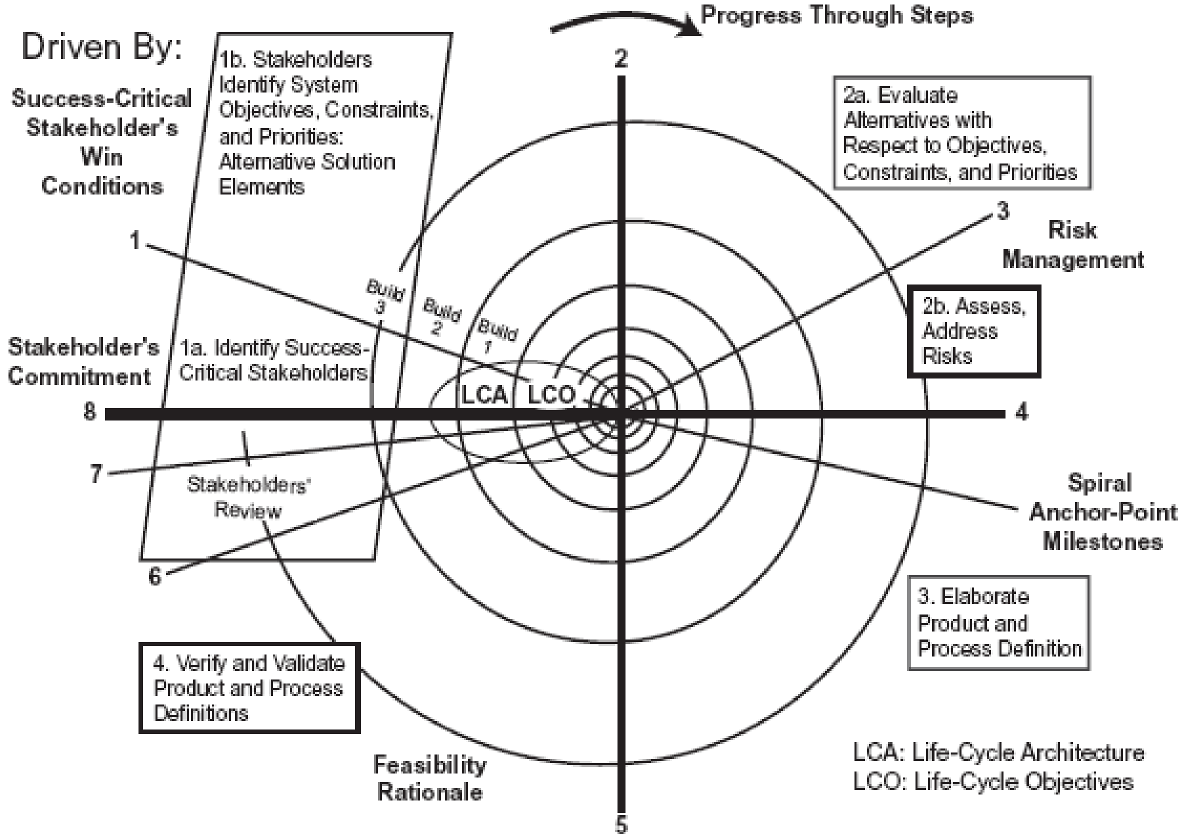
• Define the scenario: Terrain, ORBAT and Campaign Plan
• Define command and control (Exercise Control Cell)
• Define manning for exercise players, response cells, control and support
• Define C4I requirements
• Develop the training plan
• Establish database milestones and begin build
• Determine real-world logistical support
• Draft Memorandum of Agreement (MOA) or Pro Forma
• Schedule supporting training events:
  • Site survey. (pre-MPC)
  • Database builds (including 'Good Idea Cut-off Time')
  • Scenario Development (pre-MPC) and scripting (post-MPC)
  • 'Train-the-trainer' for the model and ABCS (post-MPC)
• Joint and outside agency participation
	• Present coordinated Exercise Plan to the exercise director and senior reps from key organizations:
	  • training objectives
	  • exercise objectives
	  • organizations involved and roles/responsibilities
	  • exercise directive (specified tasks and coordinating instructions)
	  • planning timeline, tasks required and tracking status
	  • scenario progress, 'Road-to-War', inject requirements
	  • technical plan, database requirements, simulation workarounds,
	  • budget and contract requirements
	  • logistical support
	  • cell structure and manning requirements
	  • communications plan
	  • O/C, AAR and collection plan
	• Identify cell OICs
		• Present final coordinated plan
		• Publish FRAGO if required
		  • Review MOA milestones, update status
		  • Resolve outstanding issues
		  • Review training objectives
		  • Review manning
		  • Review conduct of the exercise
		  • Publish Exercise Control Group
		  • Review exercise budget versus changes to projected costs
		  • Cell OICs present and provide backbriefs
		  • Review training requirements (O/C, unit, operator) prior to exercise
		  • OPFOR review

Spiral Lifecycle Model (SLM)



(Boehm 1988)

SLM Tailoring Process



At a SoS level, the SLM might be tailored for a program to include the following reviews which would occur during each phase of a SLM based program:

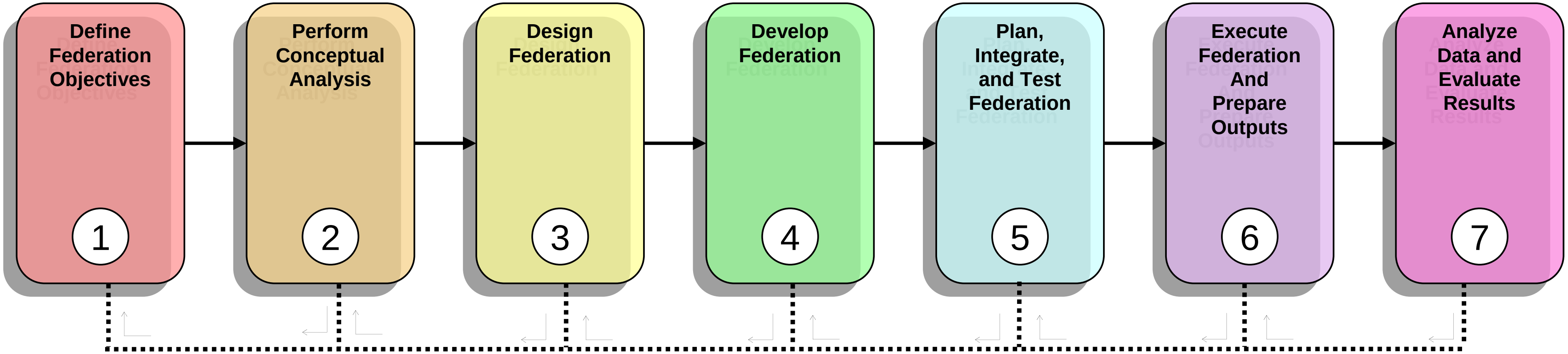
- Definition Anchor Point (**DAP**)
- Planning Anchor Point (**PAP**)
- Readiness Anchor Point (**RAP**)
- Assessment Anchor Point (**AAP**)

(Boehm 2004)

Anchor Point Definitions

- Definition Anchor Point (DAP)
  - Guidance for each phase focusing more and more on end-state product
- Planning Anchor Point (PAP)
  - High-level review of the plans, architecture, and risks for the entire spiral development
  - Detailed plans of the specific phase in question
  - Risks and integration challenges identified in the DAP
- Readiness Anchor Point (RAP)
  - Most significant checkpoint associated with each build
    - Represents commitment across all levels of a program that the software build can be successfully implemented within the build budget and schedule using the documented architectures and designs
    - Risk mitigation plans exist for all potential shortfalls
- Assessment Anchor Point (AAP)
  - Identify process improvements that can be made in subsequent phases

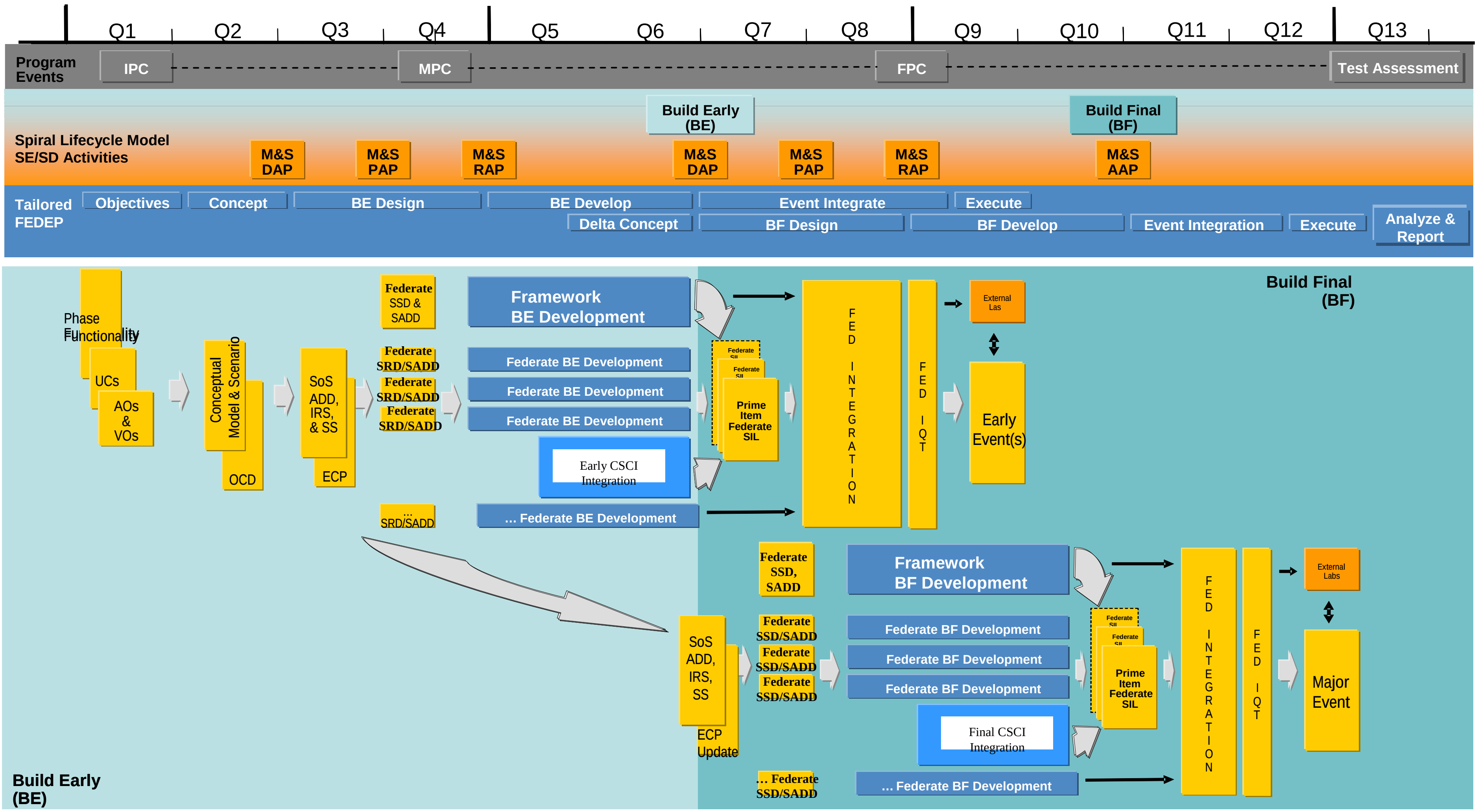
Federation Development and Execution Process (FEDEP)



Rather than dictating a "one-size-fits all" solution for all users, the FEDEP provides a common overarching process framework into which lower-level domain-specific management and/or engineering methodologies can be easily integrated.

(IEEE 1516.3)

FEDEP Alignment to FCS Milestones



Top-down Mapping Results

- One of the key goals of this paper was to identify how the FEDEP might be used in large SBA programs such as FCS.
  - Key to this is understanding how systems engineering processes interact.
- We mapped the planning conferences through the anchor points to the FEDEP recommended inputs, tasks, and outcomes.
  - Anchor points represent gating conditions or controls on the FEDEP, not technical inputs.
    - To complete this mapping, we defined four new anchor point credentials focused on reviewing planning conference outputs as inputs to the FEDEP.
- Where do the planning conferences and anchor points impact the FEDEP?

FEDEP Concurrence Points

- 1.1 - Identify User/Sponsor Needs
  - Any known constraints which may affect how the federation is developed and executed (e.g., due dates, security requirements)
- 1.2 - Develop Objectives
  - Assess federation feasibility and risk.
  - Define and document an initial federation development and execution plan.
  - Develop initial planning documents, including: Federation development and execution plan showing an approximate schedule and major milestones.
- 2.1 - Develop scenario(s)
  - Federation scenario(s)
- 2.2 - Develop federation conceptual model
  - Federation conceptual model
- 2.3 - Develop federation requirements
  - Federation requirements
  - Federation test criteria
- 3.2 - Prepare federation design
  - Federation design
  - Federation architecture (including supporting infrastructure design)
  - Implied requirements for federate modifications and/or development of new federates
- 3.3 - Prepare plan
  - Integration plan
- 4.1 - Develop FOM
  - FOM
  - FED/FDD
- 5.3 - Test Federation
  - Tested (and if necessary, accredited) federation
- 7.2 - Evaluate and feedback results
  - Lessons learned
  - Final report
  - Reusable federation products

These all represent points where the federation touches the SoS, but where M&S specific guidance is needed.

Findings

- Recognize the federation as a first-class object.
  - The tested federation, the output of FEDEP activity 5.3, must be a deliverable itself .
- Program level guidance needs to be translated into executable, M&S specific-guidance.
  - Most of our testing plans focus on testing the SoS using the federation, but there is very little information on testing the federation.
- Record both the decisions that are made and the processes by which decisions are made.
  - You may have to revisit those decisions in a later iteration, e.g. selection of existing federates to meet the requirements of a particular iteration. Knowing the criteria for the decision can expedite reevaluation.
- Federation requirements must be readily identifiable as a subset of SoS requirements.
  - Additionally, there should be continuous requirements management because delays in delivery of operational software may require filling in those items with M&S, but that too takes time.

Findings

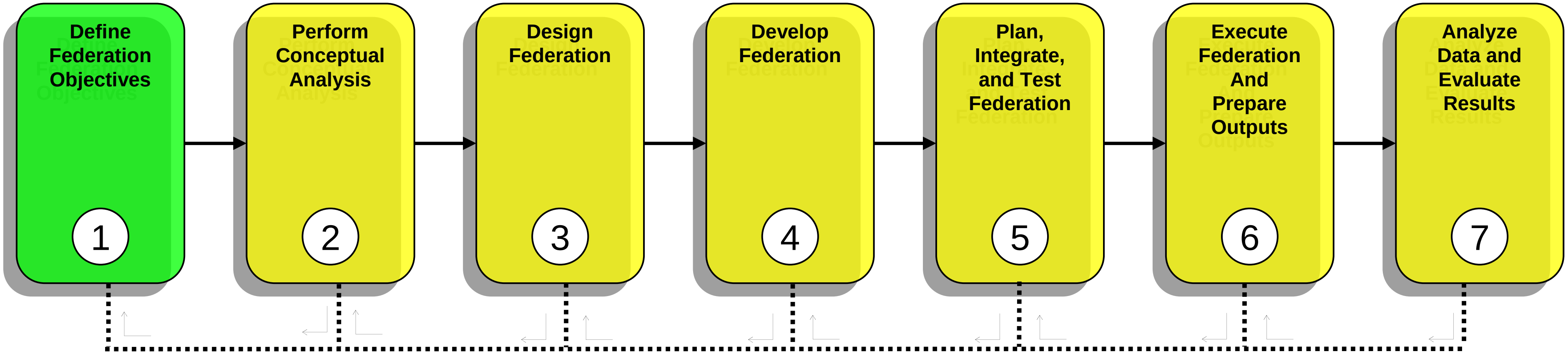
- Recognize where M&S is the same and where it's different from your operational software.
  - For example, non-operational M&S may not need as rigorous testing as operational software, but the same CM and documentation standards probably apply.
    - However, consider the global implications of relaxing standards for M&S because it may have broader implications, e.g. reducing the level of testing for M&S may reduce your ability to fully test operational software that depends on M&S.
  - Embedded M&S is operational software and should be treated as such.
- M&S can solve your representation shortfalls, **not** your interface ones.
  - M&S has to have interfaces too, preferably the same ones used for operational systems so operational code can be dropped in readily later.

Estimating Rework Across IPs

- Reviewed each FEDEP recommended task and estimated level of rework in later IPs based on the assumption that preceding IPs were successfully executed and assigned the following values:
  - 1 (green) - little to no rework in subsequent iterations. Either program level documents remain essentially unchanged or a program process is already in place that minimizes effort.
  - 2 (yellow) - some rework, but not a substantial engineering effort. Additional or updated entity or scenario representations necessitate engineering effort that ripples throughout federate and federation engineering.
  - 3 (red) - significant rework. The actual federate and federation engineering required to implement new functionality that represents the core of the iteration intent.
- Rolled up statistics to FEDEP tasks and further into FEDEP steps

	FEDEP Steps	Description	Iteration Rework Metric
1	Define Federation Objectives	Define and document a set of needs that are to be addressed through the development and execution of an HLA federation and to transform these needs into a more detailed list of specific federation objectives	1
1.1	Identify User/Sponsor Needs	Develop a clear understanding of the problem to be addressed by the federation	
1.1.2	Recommended tasks		1
1.1.2.1		Identify program objectives that motivate federation development	1
1.1.2.2		Identify available resources and known development and execution constraints	2
1.1.2.3		Document this information in a needs statement	1
1.2	Develop Objectives		
1.2.2	Recommended Tasks		
1.2.2.1		Analyze the needs statement.	1
1.2.2.2		Assess federation feasibility and risk.	2
1.2.2.3		Define and document a prioritized set of federation objectives, consistent with the needs statement.	1
1.2.2.4		Meet with the federation sponsor to review the federation objectives, and reconcile any differences.	1
1.2.2.5		Define and document an initial federation development and execution plan.	2
1.2.2.6		Identify potential tools to support the initial plan.	1

High Level Rework Analysis Results*



- Assume that the preceding iterations were correctly executed
- Step 1 represents the program level decisions, most of which were made in the first iteration.
- Most of the hard work (indicated in red in the spreadsheet) occurs in steps 2 – 4 because that's where the federate and federation engineering really happens.
- Most of the rework in steps 5 – 7 is the ripple effect of changes to federate and federation re-engineering, although the effort is declining again in step 7 due to presumed reuse of data analysis methods. Program processes mitigate the amount of rework, but changes still have to be documented and tested.

*Detail by FEDEP step in backup slides;
detail by task in 07F-SIW-083

Final Thoughts

- Program-level processes focus on cost, schedule, and risk.
- From the SoS perspective, the federation (and the FEDEP) are test tools.
- The FEDEP is focused on the technical aspects of producing a federation.
- For FCS, we're introducing criteria for gating program-level processes down to the FEDEP to align these different focuses.
- For the broader SBA community, we're providing input to the SISO update of the FEDEP to introduce the hooks necessary for a large, iterative, SBA program.

References

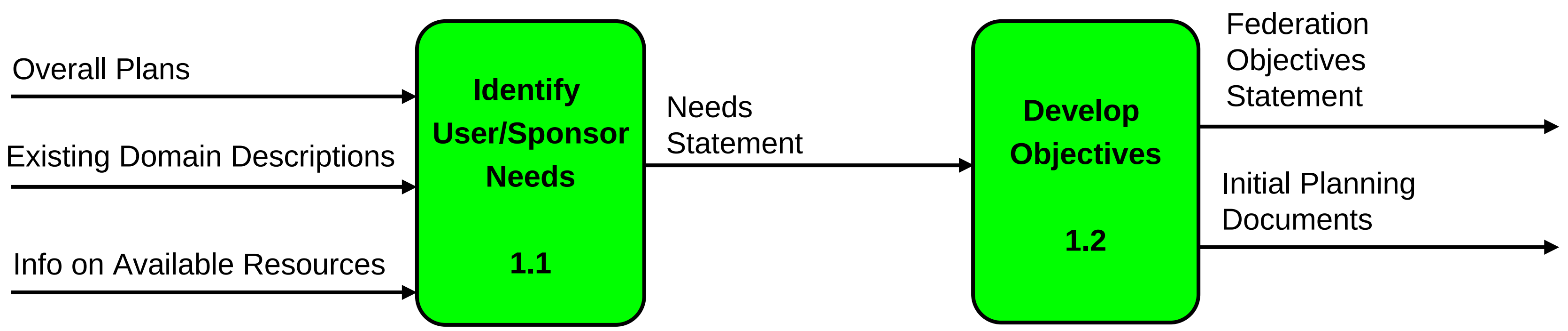
- Katherine L. Morse, Paul Lowe, Gary Fuller, and Mark Riecken, “Enhancing the Simulation Based Acquisition Process Using a Spiral Lifecycle Model Based Federation Development and Execution Process,” Proceedings of the 2007 Spring Simulation Interoperability Workshop, Norfolk, VA, March 25 – 30, 2007.
- Katherine L. Morse and Paul Lowe, “Advancing the Federation Development and Execution Process (FEDEP) for Simulation Based Acquisition (SBA),” Proceedings of the 2007 Fall Simulation Interoperability Workshop, Orlando, FL, September 16 – 21, 2007.

Backups

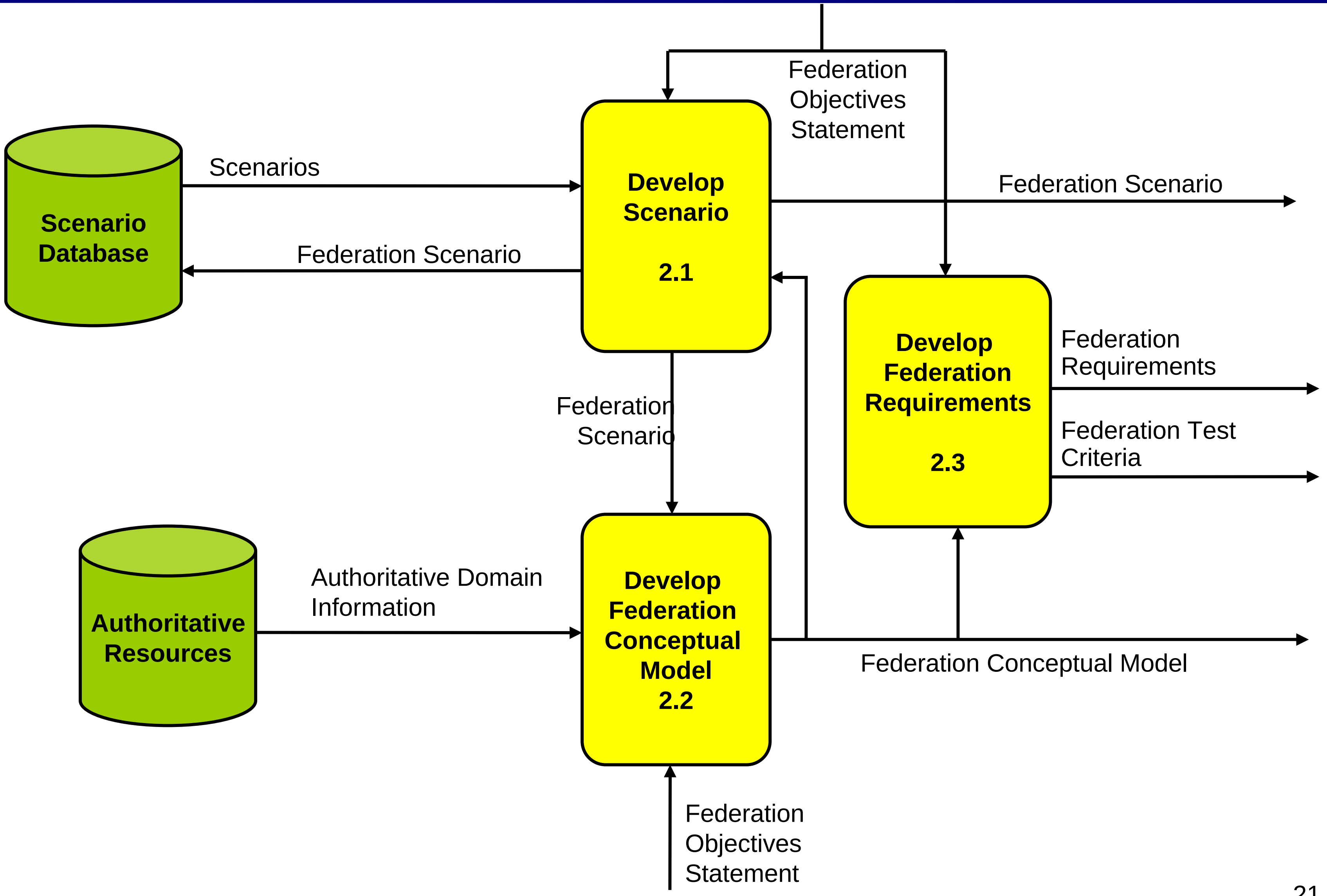
Detailed Artifact Rework Analysis

by FEDEP Step

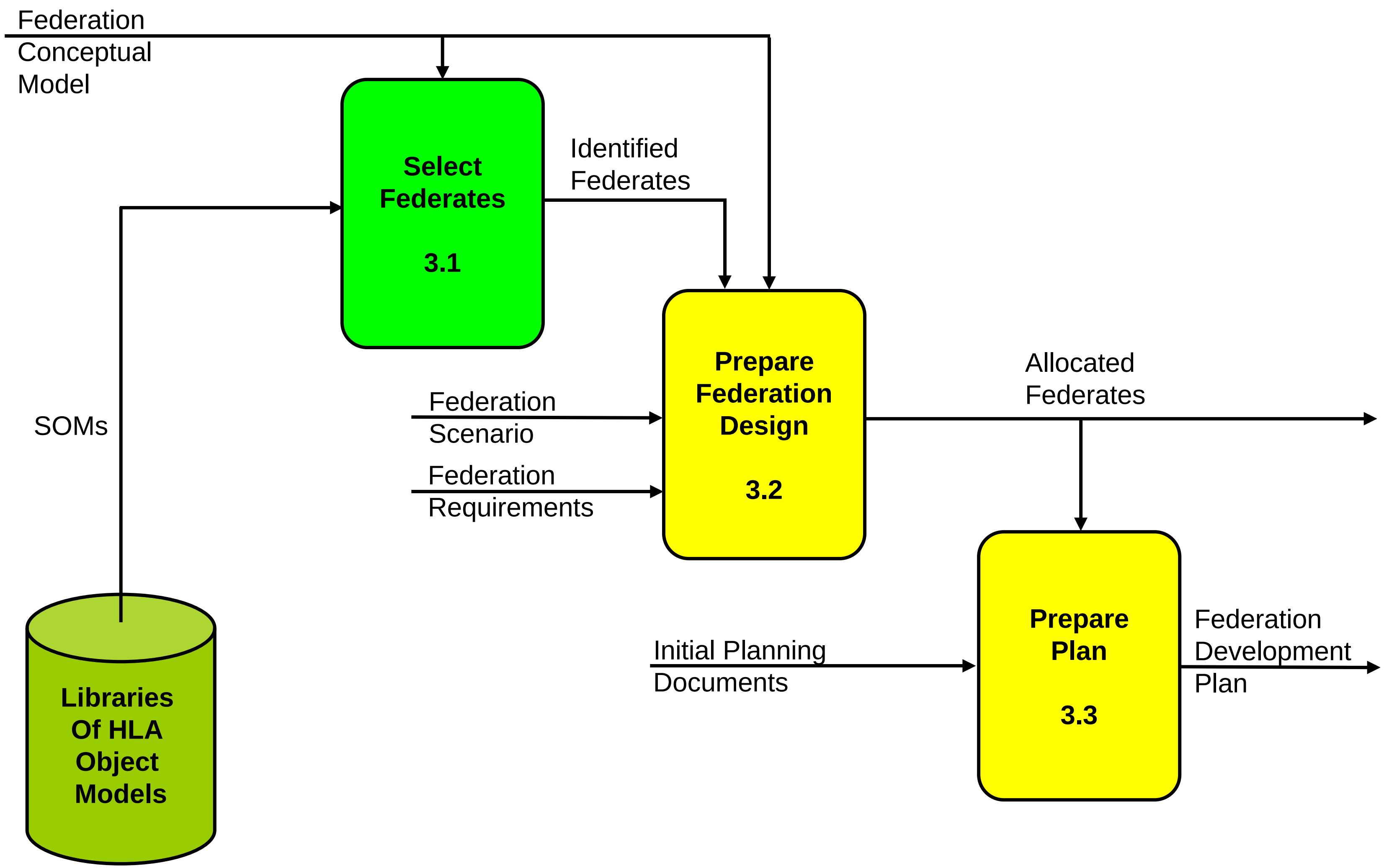
Step 1 - Define Federation Objectives



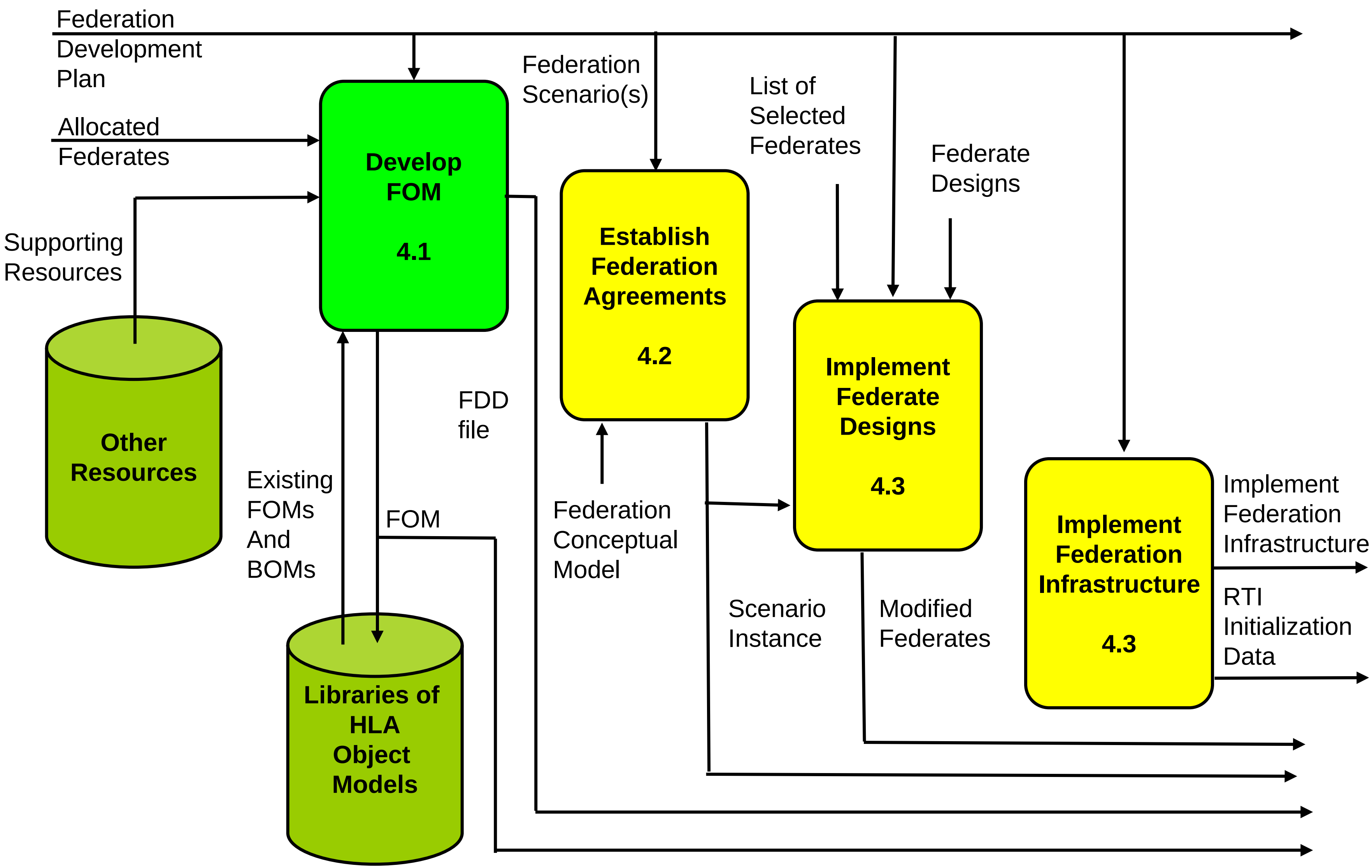
Step 2 - Perform Conceptual Analysis



Step 3 - Design Federation



Step 4 - Develop Federation



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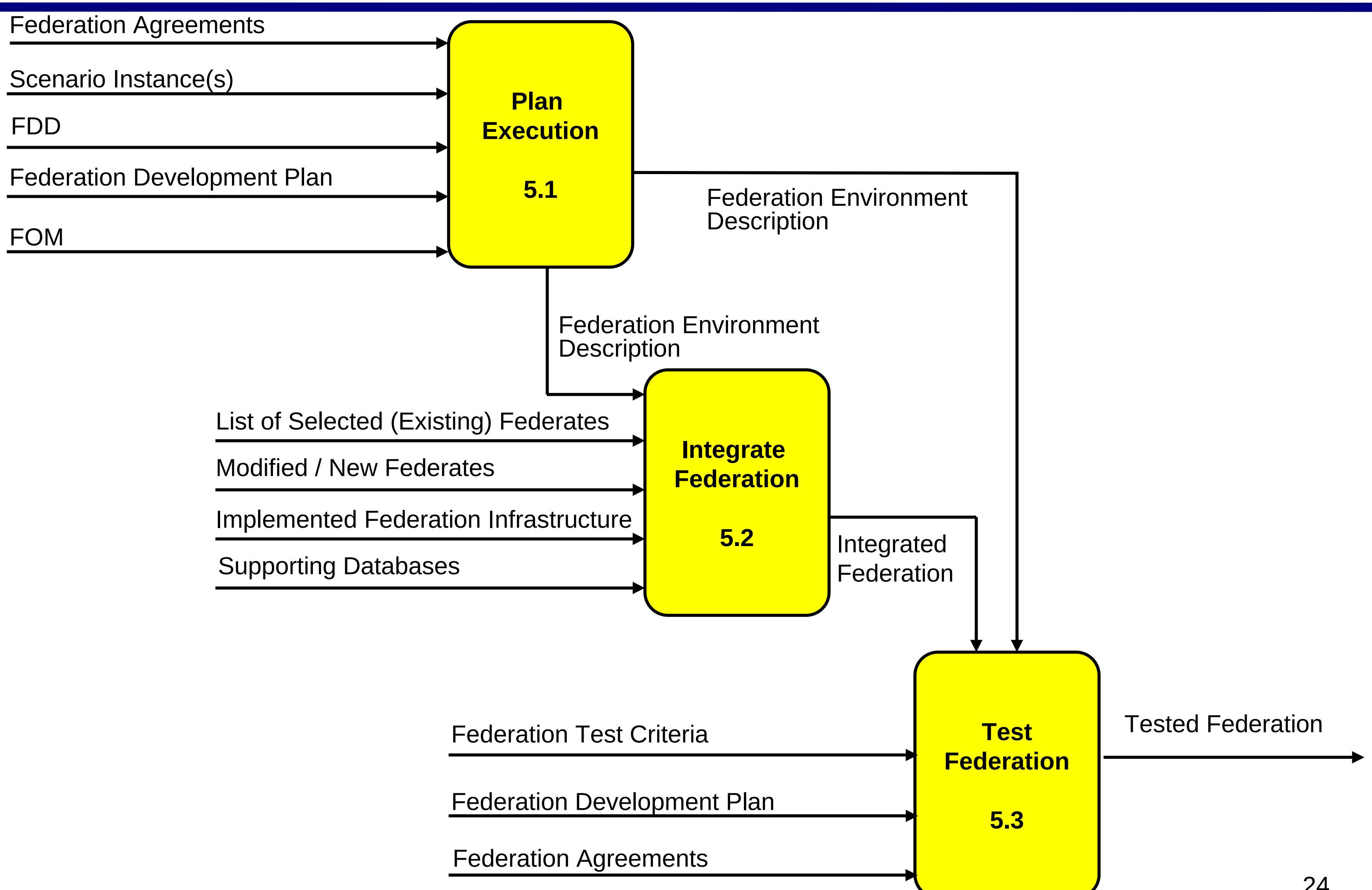
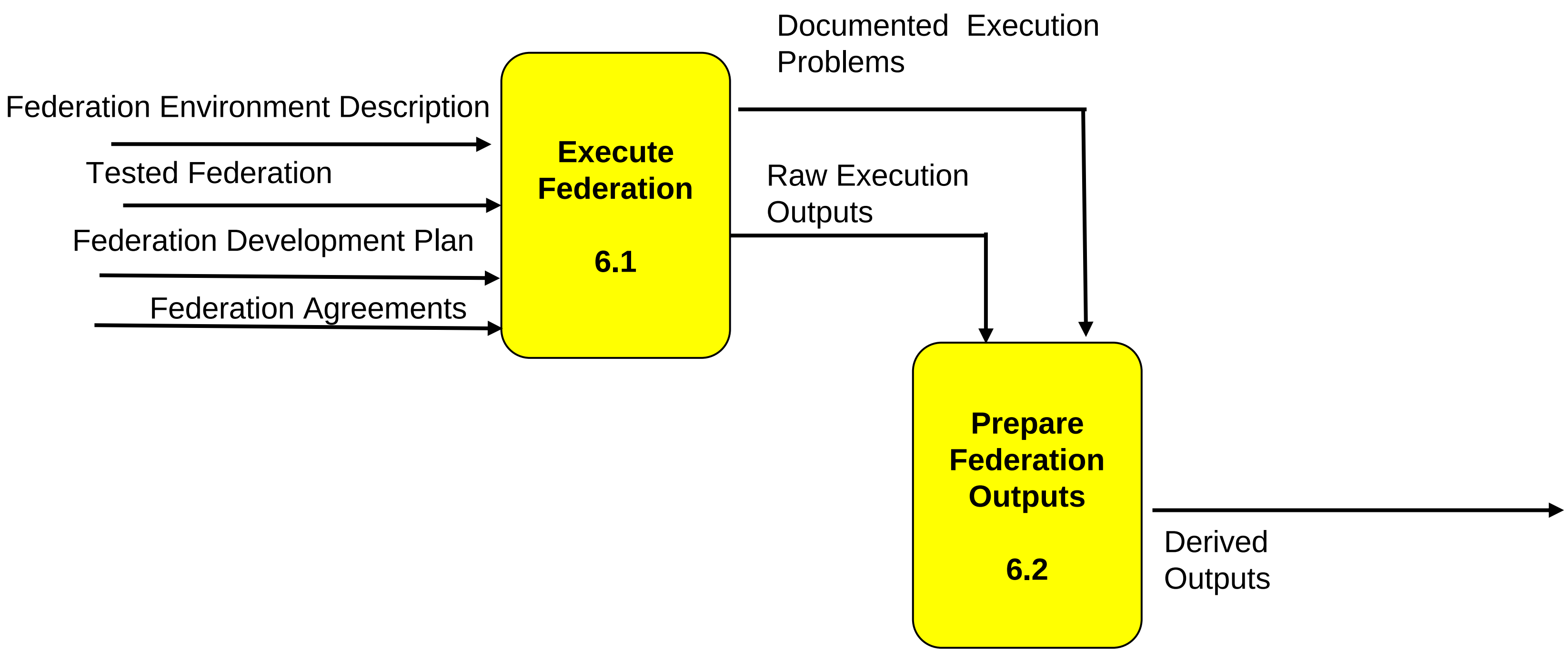
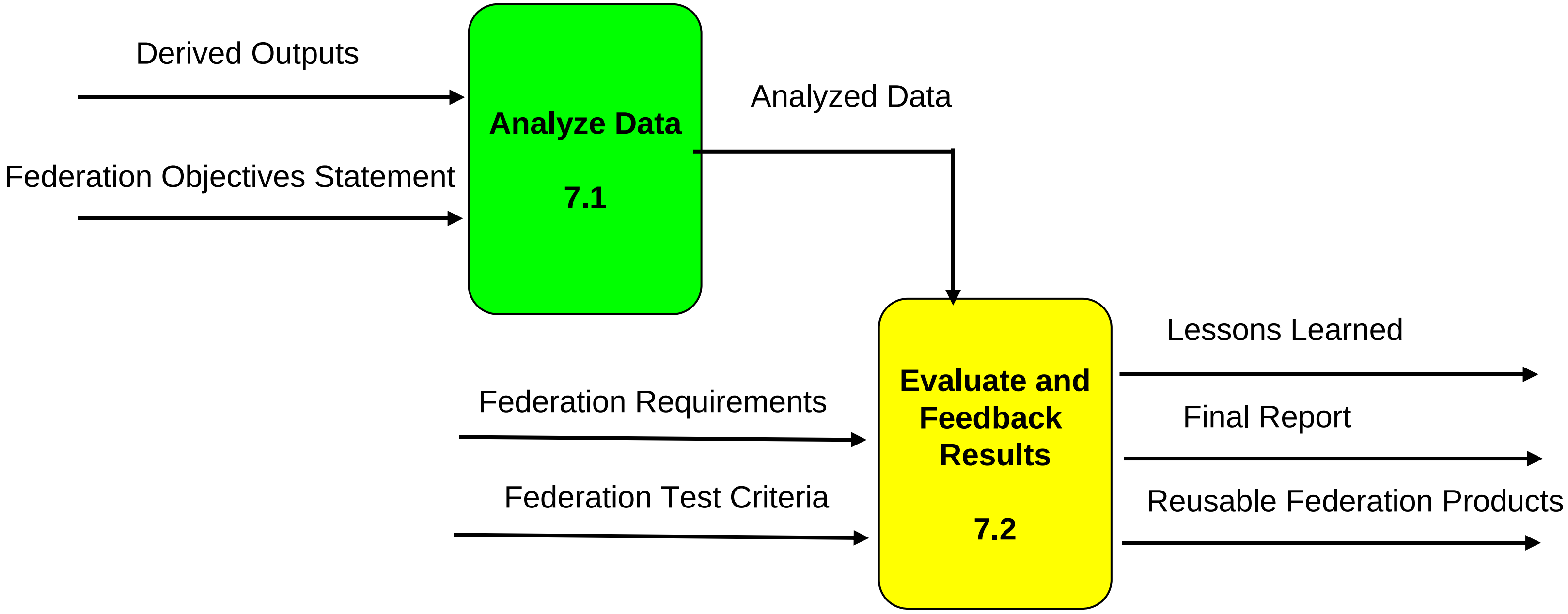
Step 5 - Plan, Integrate and Test Federation



Step 6 - Execute Federation and Prepare Outputs



Step 7 - Analyze Data and Evaluate Results



Defining Lean Service and Maintenance Processes

NDIA Systems Engineering Conference
October 2007

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"I have made this letter longer than usual because I lack the time to make it shorter"

Blaise Pascal

Presentation Objectives

Provide motivation and principles for lean, maintenance, and service.

Describe Service/Maintenance in terms of "projects" and CMMI®.

Describe successful CMMI Tailoring for Service/Maintenance Organizations.

Answer any of your questions.

Agenda

Introduction

Motivation and Background

Tailoring Project Management

Tailoring CM

Tailoring Engineering

Miscellaneous Tailoring

Questions and Answers

Lean Problems

Most organizations have too much waste (e.g., non-value added).

Most processes have too many “non-value added” steps.

How can organizations focus on “value added” and remove waste?

How can organizations measure value and waste?

Lean is a recent quality approach to help organizations focus on “value” and remove “non-value”.

What is Lean?

Lean has its roots in quality and manufacturing, and is a recent popular movement in quality.

"Lean Production" is the name for the Toyota Lean Production System.

<u>The following are major lean references (books):</u>

- **"The Machine That Changed The World"**
- **"Learning to See"**
- **"The Toyota Way"**
- **"The Toyota Product Development System"**
- **"Lean Thinking"**

Some Lean Principles - (1)

Establish customer defined value (i.e., identify the "value stream"). Process = "value".

Continuously eliminate non-value added activities (e.g., waste, rework, defects).

Use leadership and standardization to create a lean culture.

Align your organization through visual communication.

Create an optimized process flow (e.g., "Flow", "Pull", "Just-In-Time", "Leveled").

Some Lean Principles - (2)

Use lean metrics to manage the value stream.

Front-Load the process for maximum design space.

Build a learning organization to achieve lean and continuous improvement.

Adapt technology to fit your people and processes.

Strive for perfection through continuous improvement.

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Tailoring Engineering

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Questions and Answers

Some Service/Maint. Successes

HP Success Story

– Lean CMMI® L3 Process 25% of the size of HP India Process
– Very Small Projects (0.25-0.5 FTE projects)
– Includes website development
– Includes maintenance/service
– See References [Kellum 2006]

Raytheon/NASA JPL Success Story

– Documented in SEI Report
– Tailored all CMMI L3 practices in report
– Only one customer (JPL) - Simple model
– See References

Numerous CMM Success Stories

– More and more CMMI service/maintenance success stories emerging

Draft CMMI® for Service

– Has not been released by SEI

Agenda

Introduction

Motivation and Background

$\boxed{\text{Tailoring Project Management}}$

Tailoring CM

Tailoring Engineering

Miscellaneous Tailoring

Questions and Answers

Project Management PAs

Project Planning (PP - L2)

Project Monitoring and Control (PMC - L2)

Integrated Project Management (IPM - L3)
- Tailoring
- Advanced Project Management

Risk Management (RSKM - L3)

Supplier Agreement Management (SAM - L2)

• Reference: "CMMI^{SM} for Systems Engineering and Software Engineering,", CMMI-SE/SW Staged Version, Version 1.1

Project Planning Goals

SG 1: Estimates of project planning parameters are established and maintained.

SG 2: A project plan is established and maintained as the basis for managing the project.

SG 3: Commitments to the project plan are established and maintained.

• Reference: “CMMI^{SM} for Systems Engineering and Software Engineering,”, CMMI-SE/SW Staged Version, Version 1.1

Commitment Metrics

	COMMITs	Size	Effort	Cost	Schedule	Defects
Plate Full	1. 2. 3. . . . N					
Backlog	N+1 ...					

Service/Maint. Principles

The CMMI is "project" oriented. In a Service/ Maintenance organization, there may not even be a "project".

The term "Project" may not work in your organization ("Project" definition: Start Date/End Date). This can be a major problem when interpreting the CMMI for Service/Maintenance.

Most of the time, there are a collection of activities that can be grouped together:

- Releases/Bundles
- Tasks/Service Requests
- Change Requests/Problem Reports
- Annual Plans (e.g., service, maintenance)

Example Service/Maint. Plans

<u>**Possible Equivalents to CMMI Project Plans:**</u>

- **Release Plan (e.g., Annual, Quarterly, Monthly)**
- **Task Plan (e.g., for a customer under a PO)**
- **Service Request**
- **Service Level Agreement (SLA)**
- **Annual CM Plan**
  - **Change Requests(CRs)/Problem Reports (PRs)**
- **Annual Plans (e.g., service, maintenance)**
  - **Can have releases, CRs/PRs, Service Requests, Tasks**

Service/Maint. PM Tailoring

Don't change your business to match CMMI.
Improve your business to meet CMMI Goals.

Use Lean Templates that implement CMMI requirements (combine items).

Put many of the CMMI requirements that don't change across tasks in annual plans (e.g., Scope, Data, Training, Risks, CM, etc.) The things that do change (e.g., estimates, schedule, etc.), make lean and tailor to tasks.

Schedules can be very different (e.g., more focused on releases/CM than milestones).
Tracking can be done periodically (e.g., monthly), and meetings may be combined.

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Tailoring Project Management

$\boxed{\text{Tailoring CM}}$

Tailoring Engineering

Miscellaneous Tailoring

Questions and Answers

The Customer and CM

Why perform CM?

If effective CM is not performed, the risk of shipping the wrong version to a customer is too high. For example, a version delivered to a customer might …

- **Have defects**
- **Have untested changes**
- **Not be reproducible**

CM is all about "Product Integrity":

- **Knowing exactly what customers have**
- **Knowing the exact status of products, versions, baselines, configuration items (e.g., exactly what is in which version)**
- **Knowing how to reproduce every product, version, component, configuration item, etc.**

CM Principles

Configuration Identification:
- What are configuration items, and what configuration does your customer have?

Configuration Control:
- How do I control changes made to the configuration?

Configuration Status Accounting:
- What is the current status of the configuration?

Configuration Auditing:
- Does the configuration have product integrity?

• Reference: “Configuration Management” Training; Copyright © by Process Assets, LLC (PAL).

CMMI CM Goals

SG 1: Baselines of identified work products are established

SG 2: Changes to work products under configuration management are tracked and controlled

SG 3: Integrity of baselines is established and maintained

• Reference: *CMMI*SM *for Systems Engineering and Software Engineering, CMMI-SE/SW Staged Version*, Version 1.1

NASA JPL MGSS CM Process

7.1 Perform CM Planning

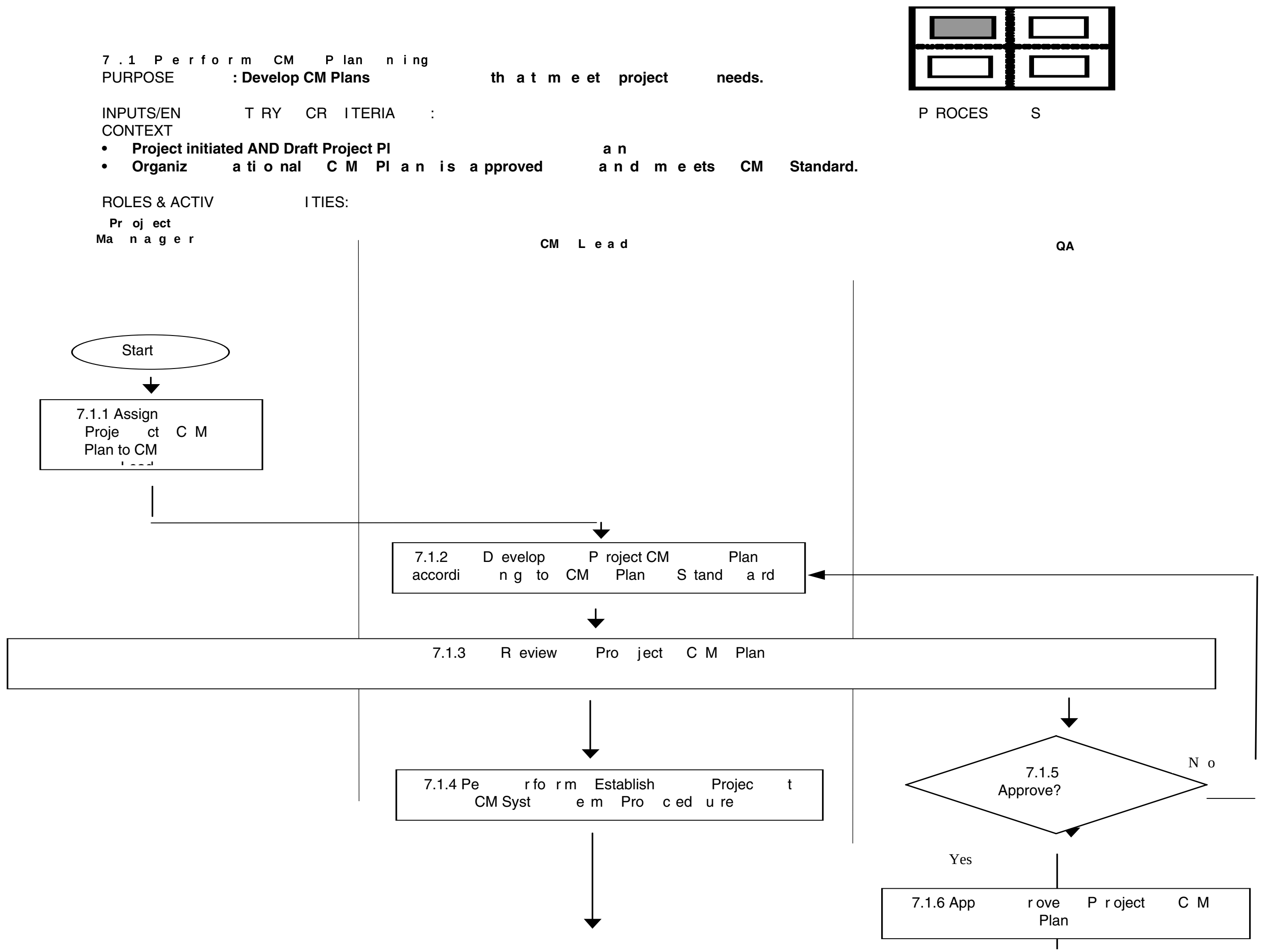
7.2 Perform Configuration Control

7.3 Perform Configuration Status Accounting

7.4 Perform CM Audits

Example CM Process

5 W's on 1 Page in a Process Model!



Patent Pending Approach

Service CM Tailoring

What is the operational definition of a "project"?

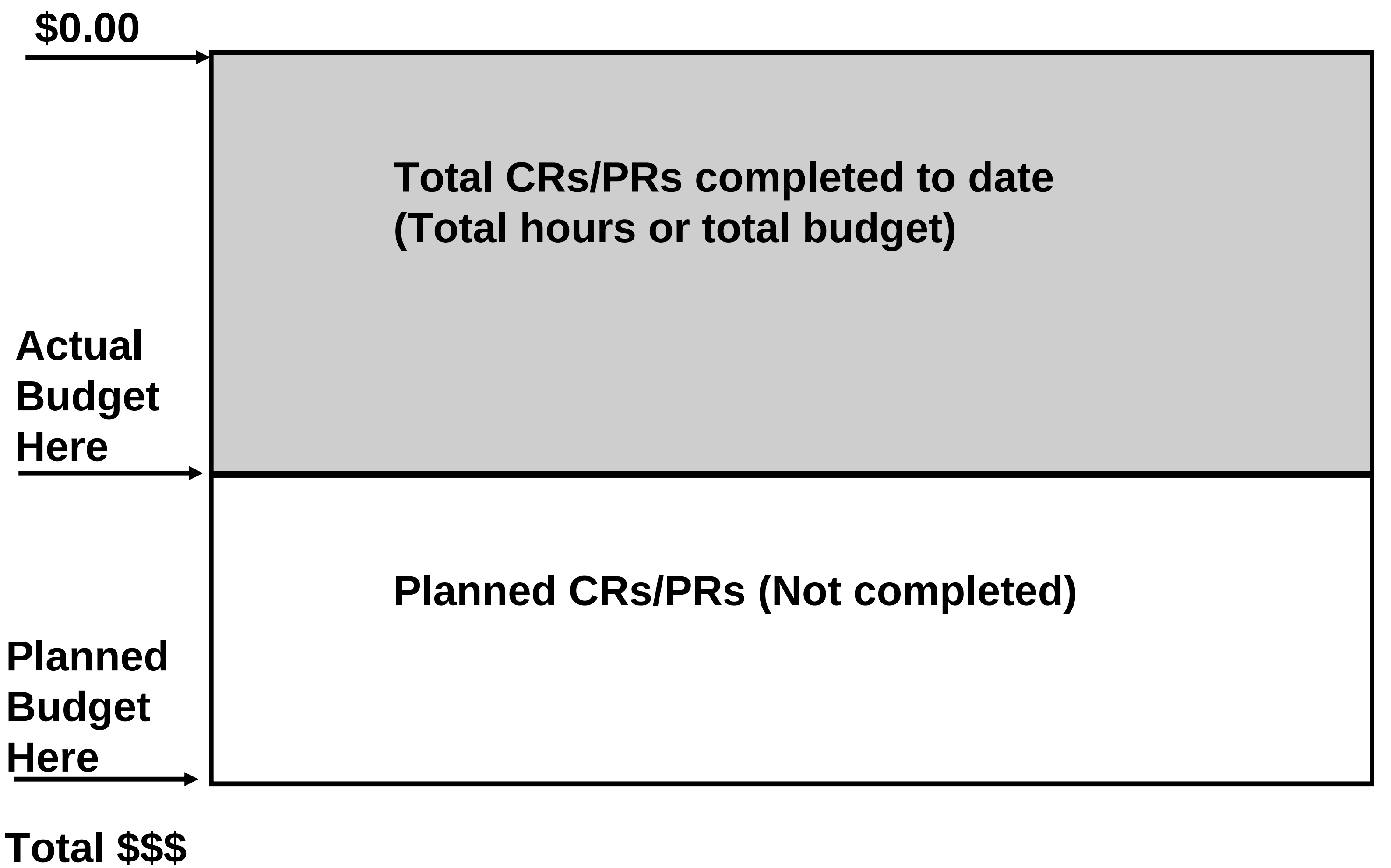
How big does a "project" need to be before it can handle the overhead of the CMMI?

Small Change Requests (CRs) and Problem Reports (PRs) are what CM is all about.

How do you plan for interrupt driven CRs and PRs? (e.g., you know the customer will make changes and you know there will be defects)

Budget for CRs/PRs based on historical data in an Annual Plan.

Annual CM plan



Agenda

Introduction

Motivation and Background

Tailoring Project Management

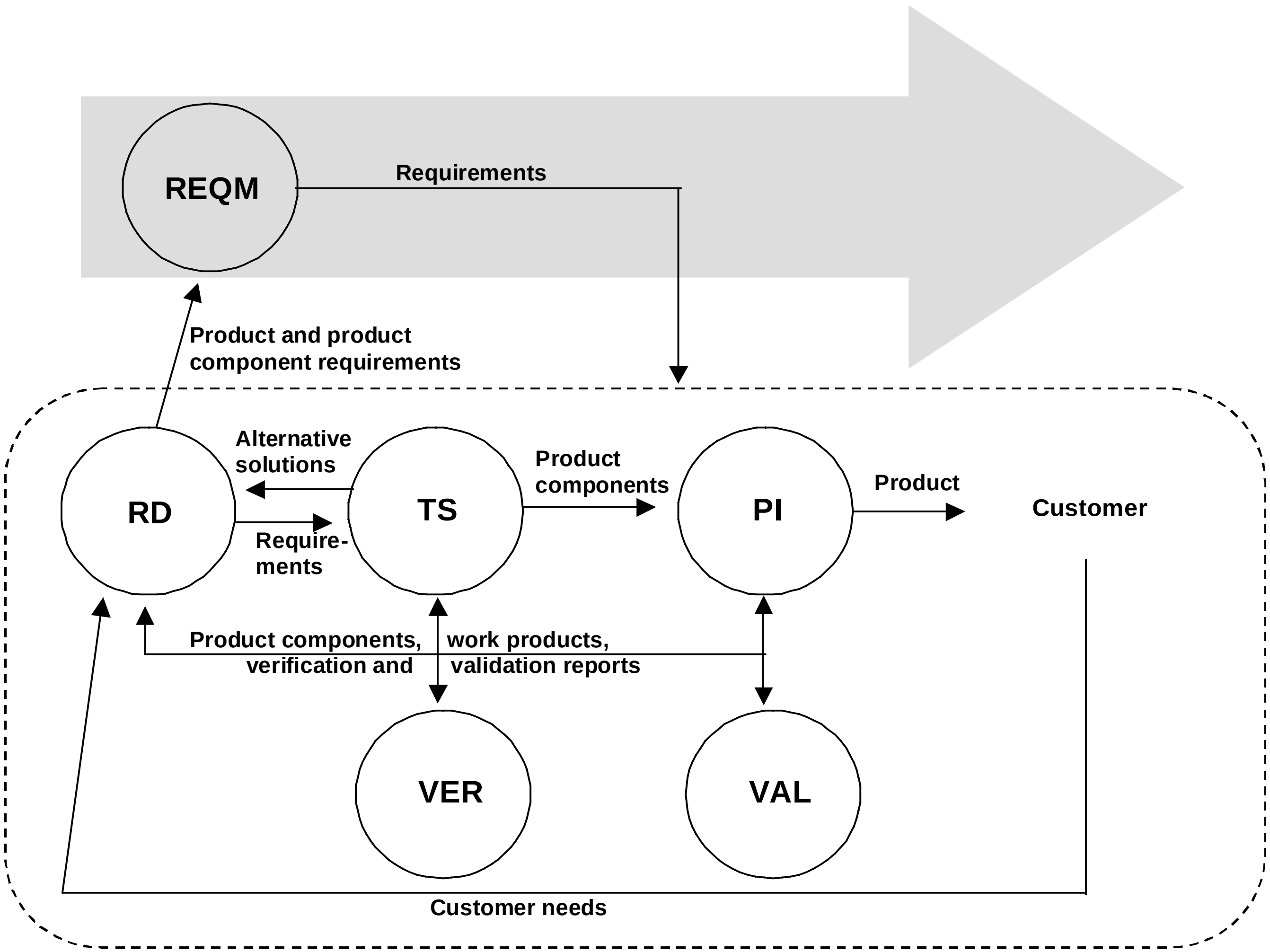
Tailoring CM

Tailoring Engineering

Miscellaneous Tailoring

Questions and Answers

Engineering Process Areas



• Reference: "CMMI[SM] for Systems Engineering and Software Engineering,", CMMI-SE/SW Staged Version, Version 1.1

Tailoring Engineering

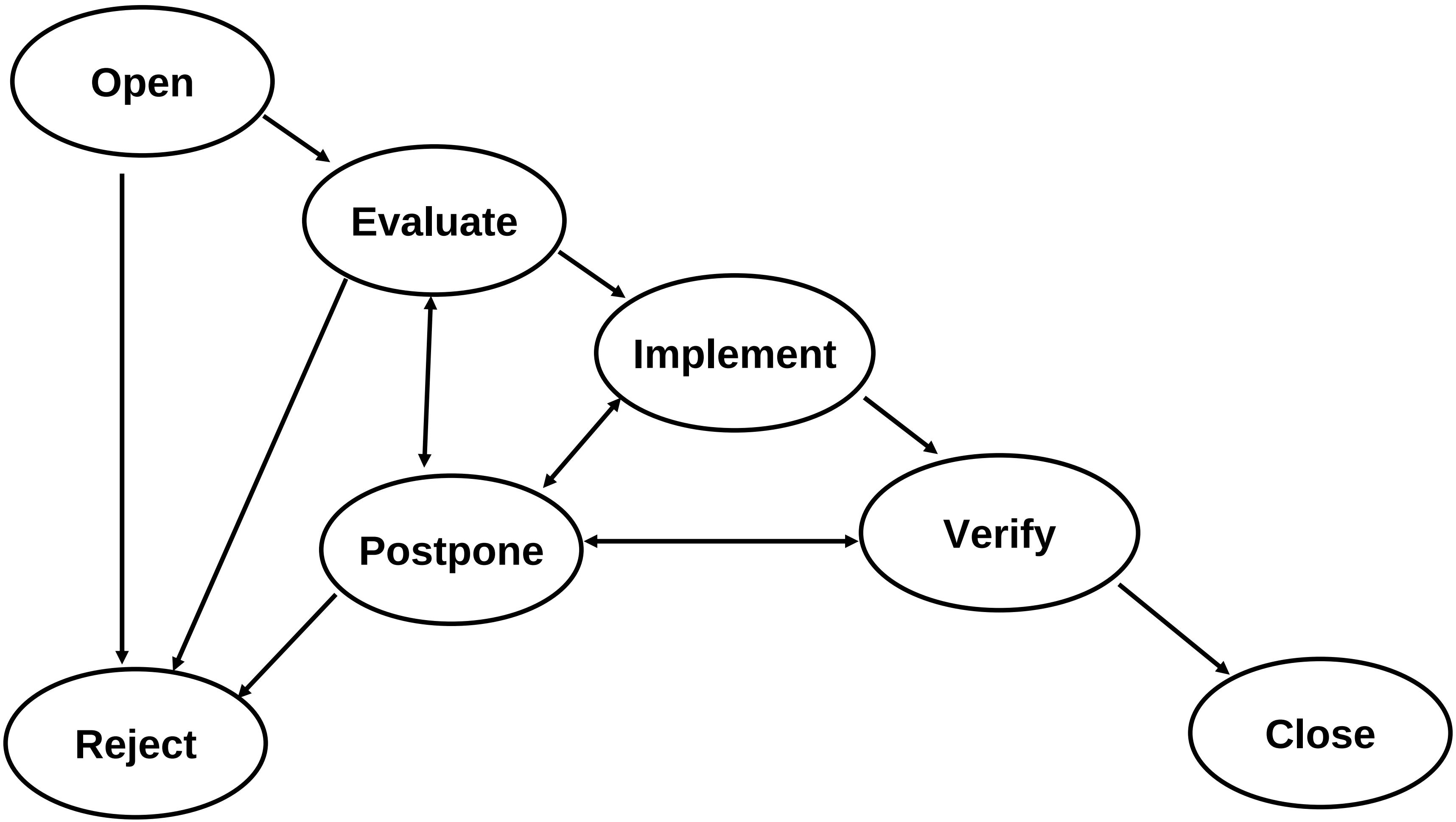
For large or medium projects (e.g., large tasks/service requests/change requests), the CMMI can be used effectively.

For small and very small stand-alone tasks, the CMMI engineering process areas have a lot of overhead. One solution is a “mini-spec”.

For very small tasks, sometimes it is better to run them under CM as a CR/PR and not formally define them as a “project”.

If desired, CM systems can be made to handle CMMI requirements.

Example CR/PR States



Example Requirements Matrix

#	Requirement	Reference	Allocation	Stability (H/M/L)	Risk (H/M/L)	Priority (H/M/L)

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Other CMMI Processes

Project Management, Engineering, CM - Covered.

Process Management PAs (i.e., OPD, OPF, OT, OPP, OID) apply well to Service/Maintenance organizations because they are at the organizational level (not the "project" level).

Most support process areas (i.e., PPQA, DAR, CAR) also apply well to Service/Maintenance organizations because they are like organizational level processes (e.g., supporting projects).

Metrics (e.g., MA, QPP) at the project level need to be tailored to Service/Maintenance organizations.

Lean Measurement Framework^{SM}

Based on three industry best practices (will be presented on next few slides).

Helps organizations focus on the “vital few” metrics.

Based on the three primary usage scenarios for metrics.

Based on metrics that are strongly supportive of goals and objectives.

Award winning measurement framework from American Society for Quality (ASQ).

Lean Measurement Framework℠

GOALS	KEY QUESTIONS	METRICS	DC	DS
PLAN		Cost, defects, effort, size, schedule, etc.		
CONTROL		Cost, defects, effort, size, schedule, etc.		
IMPROVE		Cost, defects, effort, size, schedule, etc.		

- DC = Data Collection; DS = Data Storage

Some Example Lean Metrics

Takt Time
Lead Time
Process Time
Changeover Time
Available Time
Value-Added Time
Demand Rate
Number of People
Inventory
Percent Complete and Accurate
Information Technology Used
Reliability

Data Box

Metrics are “Top Down”

Organizational vision, mission, and strategy should drive metrics. Metrics should be driven by and connect to goals and objectives.

Strategic Planning should identify measurable success criteria and measurable objectives:

- Compliance (e.g., Government requirements)
- Industry Standards (e.g., Baldrige, CMMI^{SM}, ISO, etc.)
- Market Share
- Performance (e.g., CPI, SPI)
- Productivity
- Quality
- ROI
- Time to market

Some Lessons Learned - (1)

Project management processes need the most tailoring.

CM is a strong service/maintenance process - use it!

Engineering processes need to be tailored to service/maintenance (e.g., small projects).

Organizational and support processes work well for service/maintenance.

Some Lessons Learned - (2)

Define an operational definition of a "project".

CMMI and processes must be tailored to service/maintenance organizations.

Implement a lean solution (e.g., lean processes, procedures, templates, etc). Many CMMI implementations are NOT lean.

Not every part of business needs to be under CMMI (only do what makes business sense).

Make a "project" large enough to handle CMMI overhead (i.e., should make business sense).

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References

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Modeling & Simulation for Enterprise Test and Evaluation

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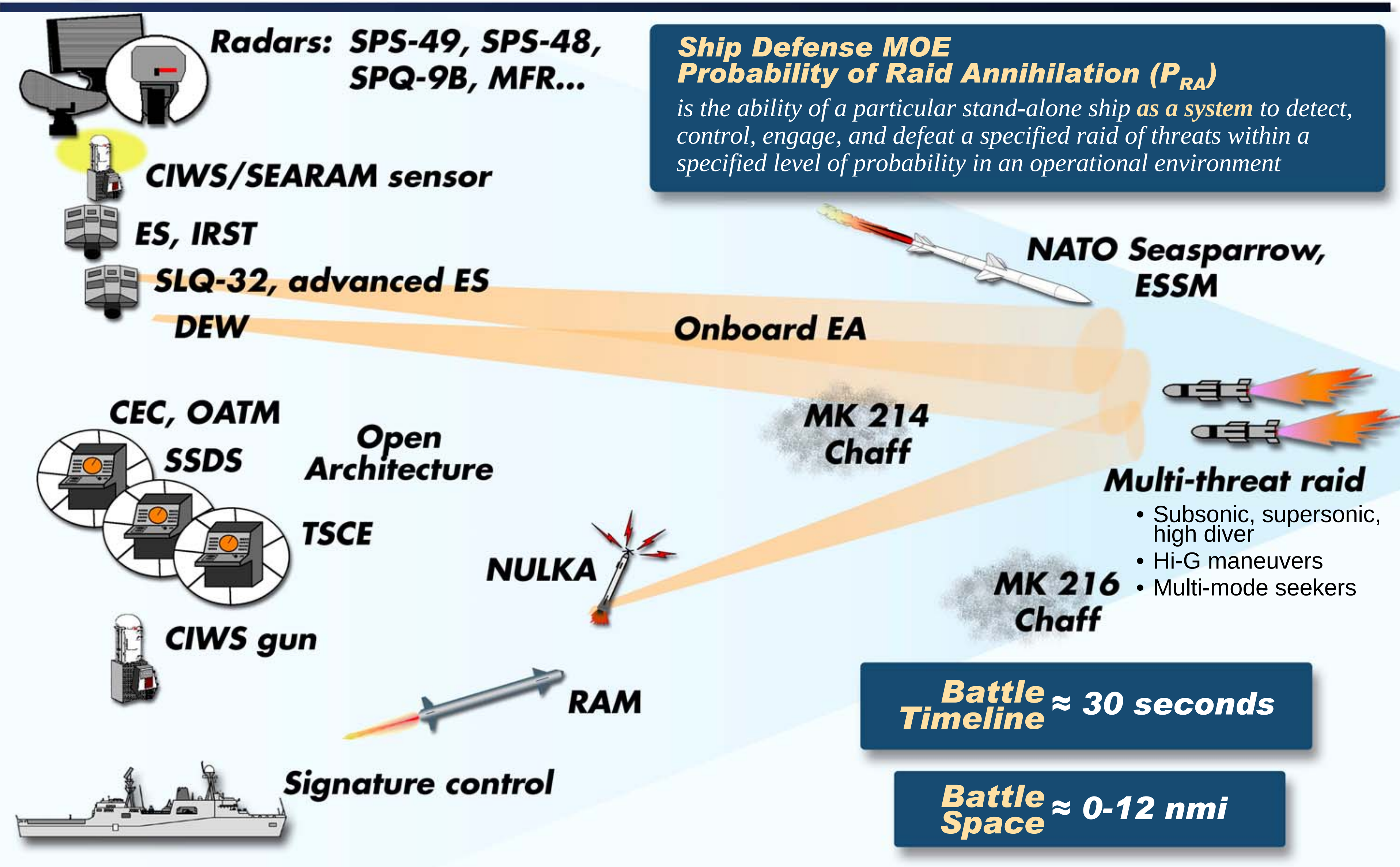
24 October 2007

Operational Context: Ship Self Defense

Ship Defense MOE
Probability of Raid Annihilation (P_{RA})
is the ability of a particular stand-alone ship ***as a system*** *to detect, control, engage, and defeat a specified raid of threats within a specified level of probability in an operational environment*



Enterprise Test & Evaluation Master Plan

UNCLASSIFIED

(U) Test and Evaluation Master Plan
No. 1714

Capstone Enterprise Air Warfare
Ship Self-Defense

25 May 2006

Department of the Navy
PEO IWS

UNCLASSIFIED

The purpose of the Capstone Enterprise Air Warfare Ship Self Defense (AW SSD) Enterprise Test and Evaluation Master Plan (TEMP) is to consolidate all AW SSD at-sea testing and P_{RA} Testbed testing

The AW SSD T&E Enterprise Strategy is founded on a two-tiered process to assess AW SSD warfare systems performance:

1) Validate models with live testing
   - Operational Ship testing
   - Self Defense Test Ship (SDTS) testing
2) Assess performance with models

Test Events DT/OT-ET15 thru ET19 are formal P_{RA} Testbed events

Includes DDG 1000, LHA 6, LCS and CVN 21 ship classes

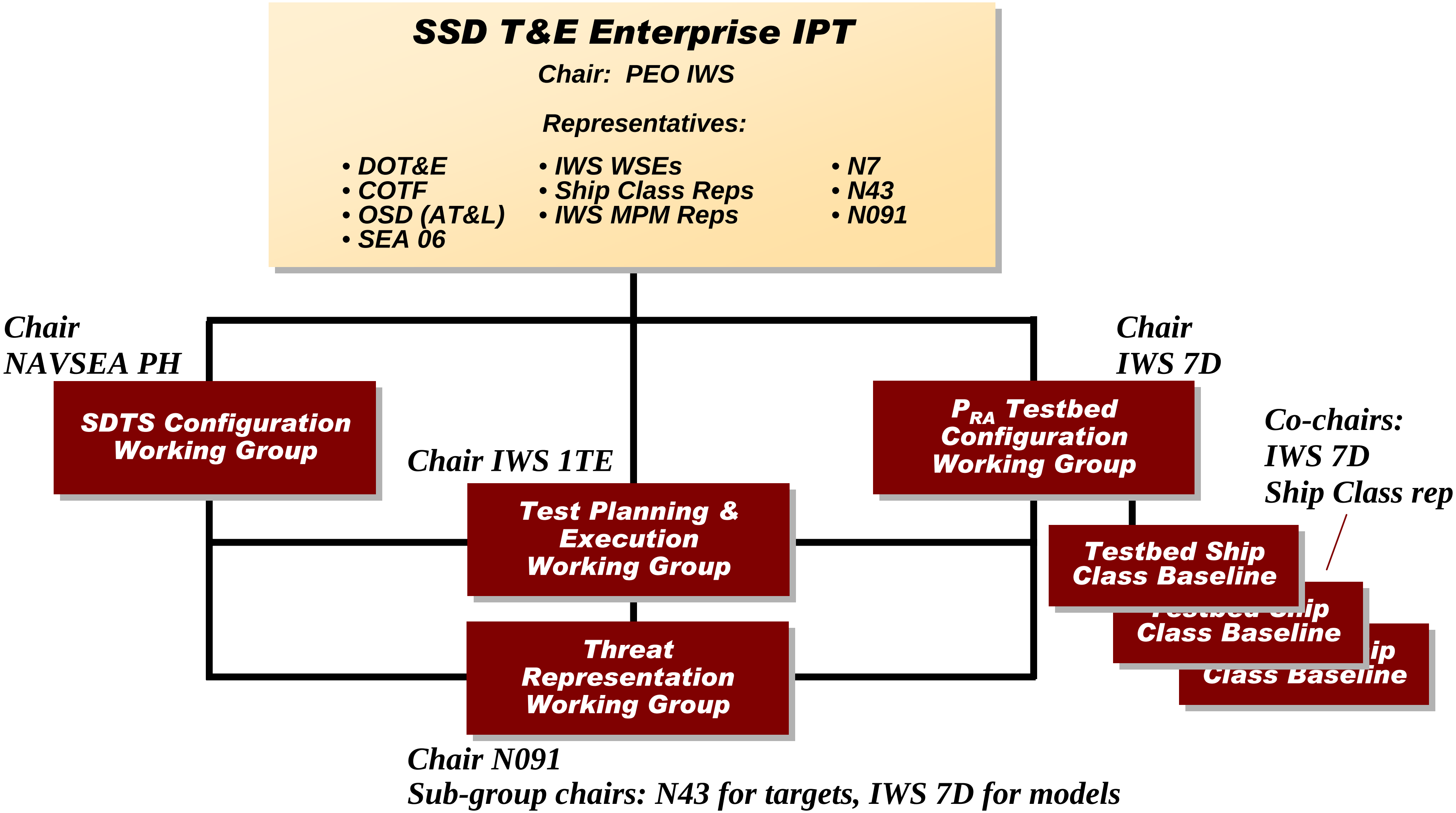
Enterprise P_{RA} Testbed System Engineering – Drivers for Centralized IWS Leadership

- **Systems performance for P_{RA} assessment spans different technical communities and multiple managing program offices**
- **P_{RA} will be assessed using a federation of interoperable simulations; it will not (cannot) be tested empirically**
  - Complex, multi-spectral, integrated HK/EW problem space
- **Many specific parameters, assumptions, and limitations are negotiated between the testing and acquisition communities**
- **The testing community is intent on consistent P_{RA} assessment across ship classes and warfare system configurations**
  - Different hulls, different configurations…same threat models, same virtual range conditions

Enterprise Test Planning & Execution

- **Non-traditional factors**
  - M&S events as formal test events
    - "Virtual Range" requirement
  - Expectation for formal, planned data flow from empirical testing to model validation
- **Organization and planning are combat-system-centric vice platform-centric**
  - Single Enterprise Test Team
  - Centralized management and resourcing of P_{RA} Testbed
  - Multiple ship classes provide testing data supporting P_{RA} Testbed component development and validation

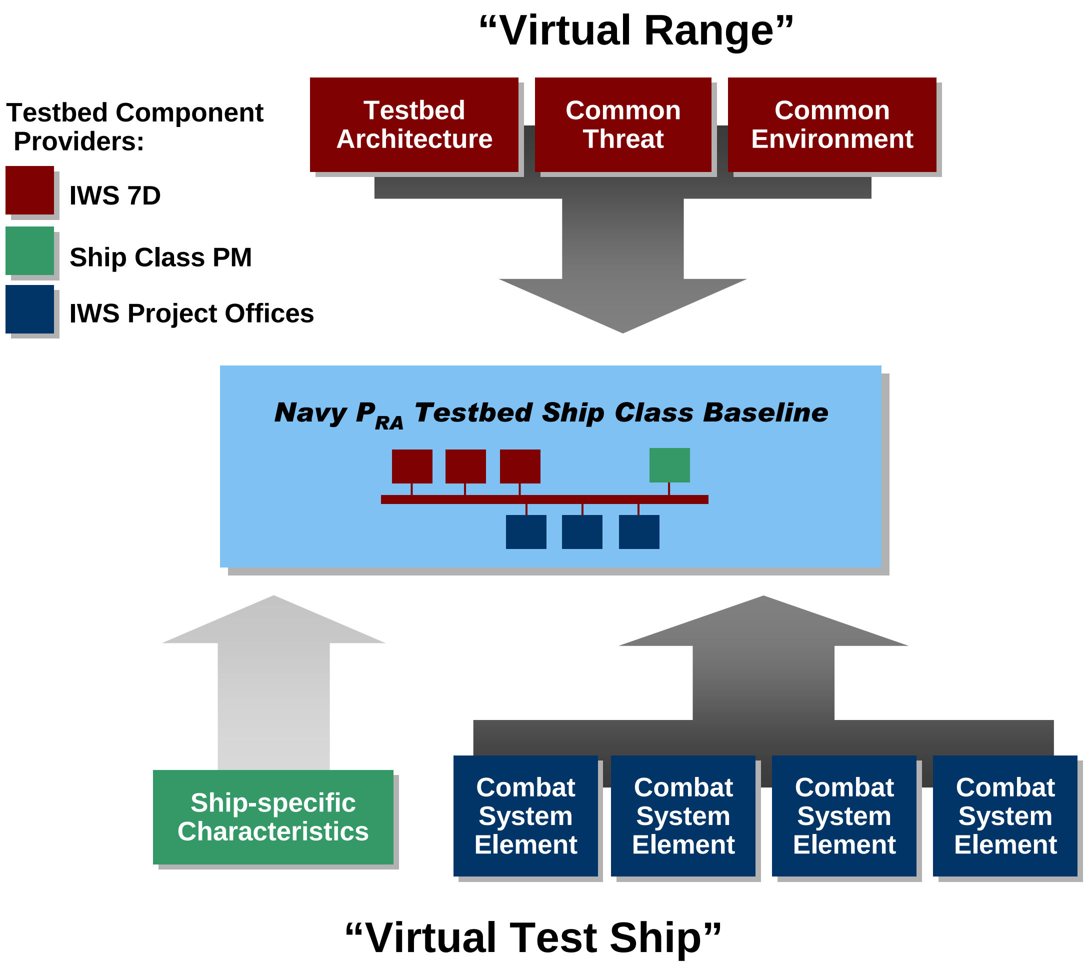
Navy Ship Self Defense T&E Enterprise IPT Structure



Enterprise P_{RA} Testbed System Engineering

- **Engineering one Enterprise Testbed, which is instantiated in several unique configuration baselines**
  – Formally accredited Baselines are correlated to Enterprise test events and ship class OPEVALs
  – Element Project Offices are vendors to Enterprise not individual ship classes
- **One master set of requirements for the Testbed**
  – Fed by both Enterprise SE and Baseline IPTs
  – Allocated and adjudicated according to Enterprise deliveries
- **A single Enterprise delivery may provide capability to more than one Testbed Baseline**
  – A single set of SE artifacts is maintained at the Enterprise level
- **Testbed-based Enterprise test events will be treated as empirical events**
  – E.g., test readiness reviews, test objectives

Enterprise P_{RA} Testbed Components



"Virtual Range" (Infrastructure)

- Testbed Architecture: network interface layer, interface standards, functional allocation standards
- Common Threat Models: seeker, airframe/autopilot, signatures, vulnerability
- Common Environment Models: tailored authoritative databases, runtime environment data services

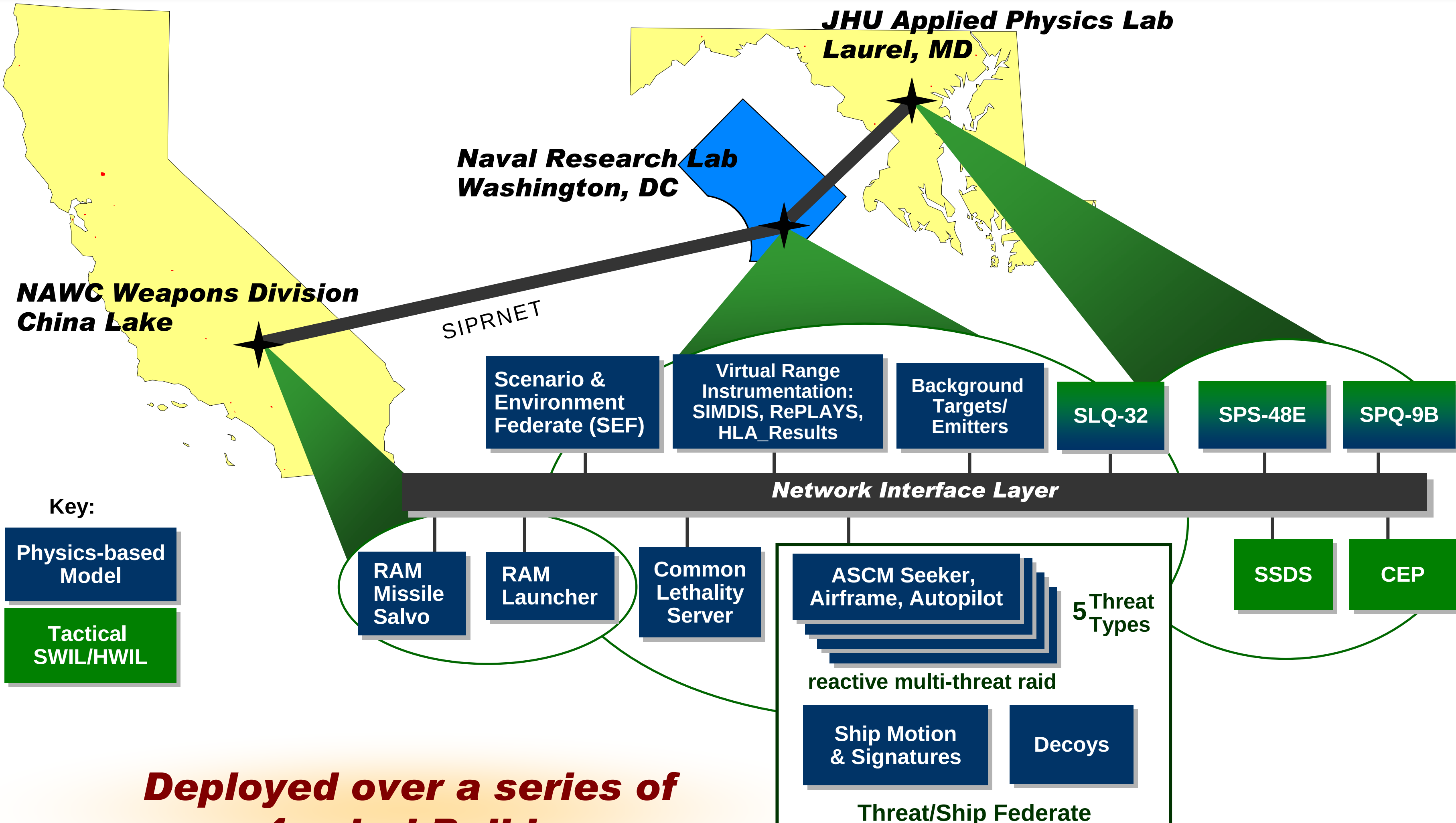
"Virtual Test Ship"(specific to ship class)

- **Ship Characteristics**
  - Signature, motion, launcher placements, etc.
- **Combat System Representation**
  - Authoritative, "T&E quality" models of combat system elements

Current Simulation Framework Characteristics

- **HLA federation implementation**
  - All system representations execute simultaneously for each ship defense engagement
- **Geographically distributed**
- **Constructive simulation, conservative time management**
- **System representations are a mix of digital models and tactical software**
  - Most representations are a hybrid of tactical SWIL and digital model
  - Most tactical SW re-hosted to general purpose computers

P_{RA} Testbed Deployment LPD 17 Baseline

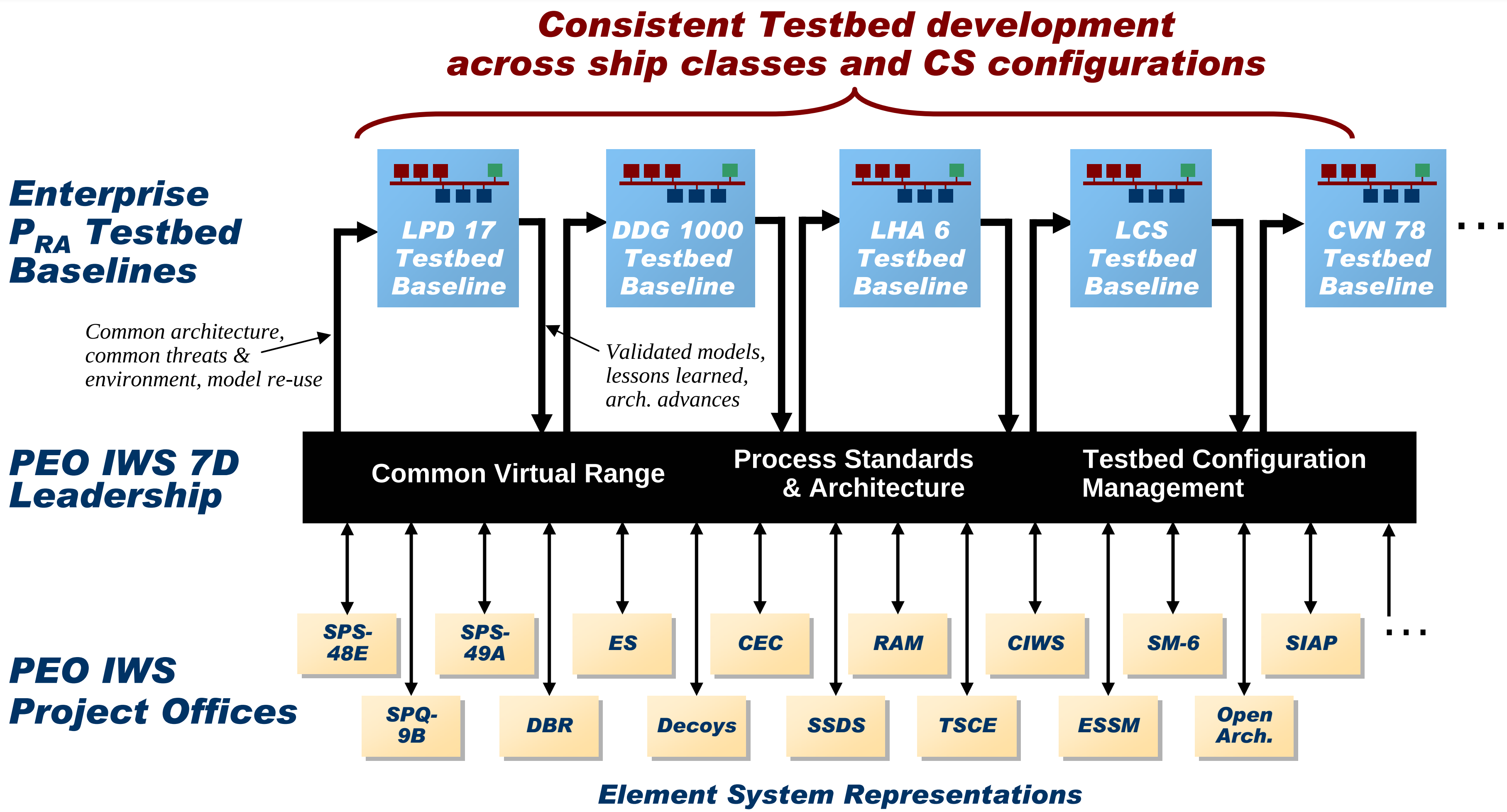


Deployed over a series of 4 spiral Builds

Enterprise P_{RA} Testbed Status

- **P_{RA} Testbed Configuration Working Group Established Under Ship Self Defense T&E Enterprise**
  – Chaired by IWS 7D, Shala Malone
  – Testbed baseline IPTs established for current Enterprise ship classes: LHA 6, DDG 1000, CVN 21, and LCS
- **LPD 17 Testbed Development Underway in Support of Ship Class OT&E**
  – 4th spiral integration underway
  – LPD 17 assessment 'runs for score' commence 1QFY08; completion planned for CY08

Enterprise P_{RA} Testbed Evolution



Significant cost avoidance through re-use of models, virtual range, & architecture

Challenges Ahead

- **Feedback of knowledge and capabilities to early phase acquisition systems engineering**
- **Improved mechanisms for injecting data needs into planning of empirical tests**
- **Relationship of P_{RA} Testbed simulations to other M&S supporting system development and T&E**
- **M&S capabilities development to support Family-of-Systems development**

Questions?

How To Measurably Improve Your Requirements

NDIA Systems Engineering Conference
October 2007

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Objectives

Describe some requirements problems from industry.

Present a useful classification of requirements problems.

Describe some practical strategies and best practices that organizations have used to successfully develop, manage, and improve their requirements in a measurable way.

Provide real examples that address requirements problems.

Answer any of your questions.

Outline

Why Focus on Requirements?

A Practical Requirements Classification

CMMI® Requirements Overview

Practical Approaches for Requirements

Requirement Examples

Some Advanced Approaches

Summary

Why Focus on Requirements?

The hardest single part of building a system is deciding what to build...
No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later.

Adapted from Fredrick Brooks, Jar. [Brooks 87]

Why Focus on Requirements?

A research report from the Standish Group highlighted the continuing quality and delivery problems in our industry and identified three leading causes:

- Lack of user input
- Incomplete requirements and specifications
- Changing requirement specifications

- Reference: "Chaos", Compass, The Standish Group, 1997, used with permission.

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Problems with Requirements

According to the SEI [Christel 92], problems of requirements elicitation can be grouped into 3 categories:

1. **<u>Problems of Scope:</u> the requirements may address too little or too much information.**

2. **<u>Problems of Understanding:</u> problems within groups as well as between groups such as users and developers.**

3. **<u>Problems of Volatility:</u> the changing nature of requirements.**

Scope and Volatility

The list of 10 requirements elicitation problems given in [McDermid 89] can be classified according to the 3 categories in [Christel 92]:

Problems of Scope

- The boundary of the system is ill-defined
- Unnecessary design information may be given

Problems of Volatility

- Requirements evolve over time

Problems of Understanding

- Users have incomplete understanding of their needs
- Users have poor understanding of computer capabilities and limitations
- Analysts have poor knowledge of problem domain
- User and analyst speak different languages
- Ease of omitting "obvious" information
- Conflicting views of different users
- Requirements are often vague and untestable, e.g., "user friendly" and "robust"

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Requirements Management (REQM)

SG 1: Manage Requirements:

SP 1.1-1: Obtain an Understanding of the Requirements

SP 1.2-2: Obtain Commitment to Requirements

SP 1.3-1: Manage Requirements Changes

SP 1.4-2: Maintain Bidirectional Traceability of Requirements

SP 1.5-1: Identify Inconsistencies between Project Work and Requirements

• Reference: "Capability Maturity Model® Integration (CMMI), Version 1.1", CMU/SEI-2002-TR-011, March 2002

Requirements Development (RD)

SG 1: Develop Customer Requirements:

SP 1.1-1: Collect Stakeholder Needs

SP 1.1-2: Elicit Needs

SP 1.2-1: Develop the Customer Requirements

SG 2: Develop Product Requirements:

SP 2.1-1: Establish Product and Product-Component Requirements

SP 2.2-1: Allocate Product-Component Requirements

SP 2.3-1: Identify Interface Requirements

SG 3: Analyze and Verify Requirements:

SP 3.1-1: Establish Operational Concepts and Scenarios

SP 3.2-1: Establish a Definition of Required Functionality

SP 3.3-1: Analyze Requirements

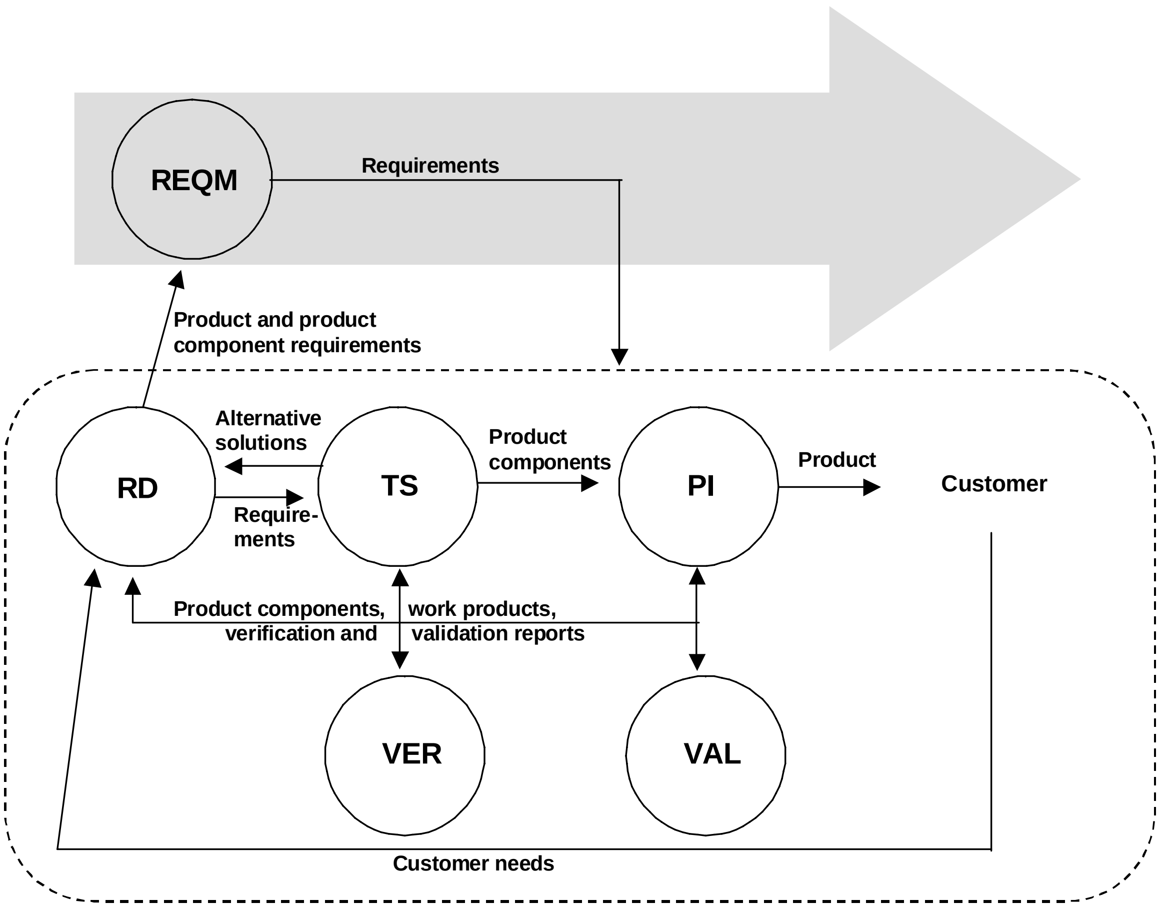
SP 3.4-3: Analyze Requirements to Achieve Balance

SP 3.5-1: Validate Requirements

SP 3.5-2: Validate Requirements with Comprehensive Methods

- Reference: "Capability Maturity Model® Integration (CMMI), Version 1.1", CMU/SEI-2002-TR-011, March 2002

Engineering Process Areas



• Reference: "Capability Maturity Model® Integration (CMMI), Version 1.1", CMU/SEI-2002-TR-011, March 2002

CMMI and Requirements

Requirement processes need to be defined, trained, and improved (e.g., OPF, OPD, OT, OID).

Support processes are critical for measuring and managing requirements (e.g., CM, MA, PPQA).

Defects need to be removed and prevented in requirements (e.g., PI, VER, VAL, CAR).

IPPD (i.e., integrated product teams) also contains allocating requirements to teams (e.g., IPM).

Supplier Sourcing requires managing supplier requirements (e.g., SAM).

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Practical Strategies

1. Define a lean Requirements Management (REQM) Process.

2. Use lean Configuration Management (CM) and CM Metrics.

3. Use Requirements Metrics (e.g., priority, stability, risk, number of requirements, defect density, etc).

4. Define the requirements process (RD), and use lessons learned from quality (e.g., QFD, Juran, etc).

5. Tailor a requirements standard (e.g., IEEE).

6. Use early defect detection and defect prevention.

7. Use operational definitions to define requirements.

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$\boxed{\text{Requirement Examples}}$

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Summary

1. Define Lean Requirements Processes (REQM, RD)

- Customer Requirements → **Develop Requirements (RD)** → • Product Requirements

- Change Requests
- Problem Reports

→ **Manage Requirements (REQM, CM)** →

- Updated Customer Requirements
- Updated Product Requirements

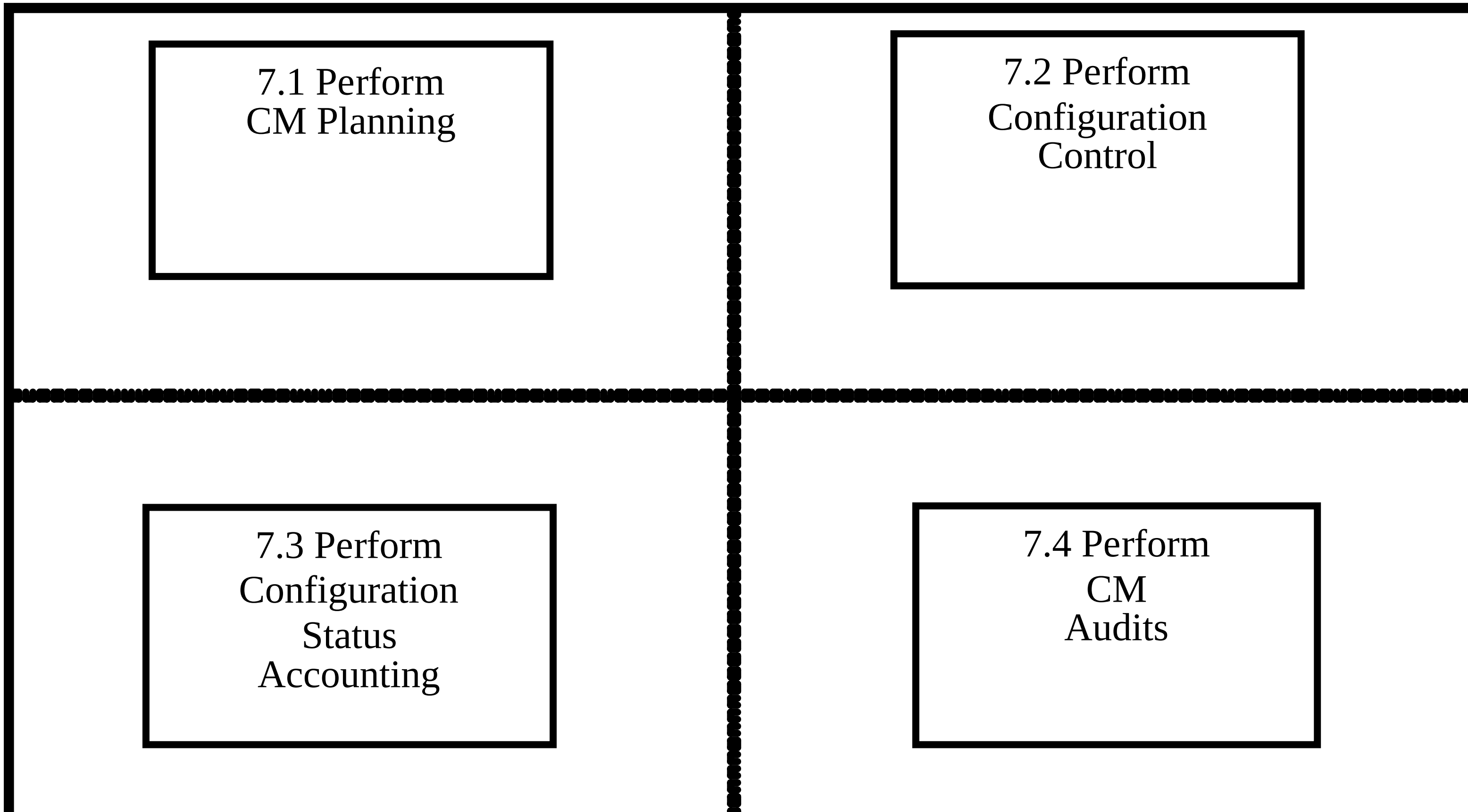
1. Manage Requirements (REQM)

Purpose: Effectively Manage Requirements Changes

Inputs	Entry	Tasks	eXit	Outputs
• Customer Req. • Product Req. → • Change Requests • Problem Reports	Cust Req./ Prod Req. Inspected AND Baselined AND CR/PR's Not all Closed	1. Perform CCB Meeting Procedure 2. Perform Change Control Procedure 3. Perform Release Procedure Best-In-Class Metrics	• CR/PRs are Resolved AND Cust Req./ Prod Req. Inspected AND Under CM	• Customer Req. • Product Req. → • Baselines • Releases

Roles: Project Manager (PM), CCB

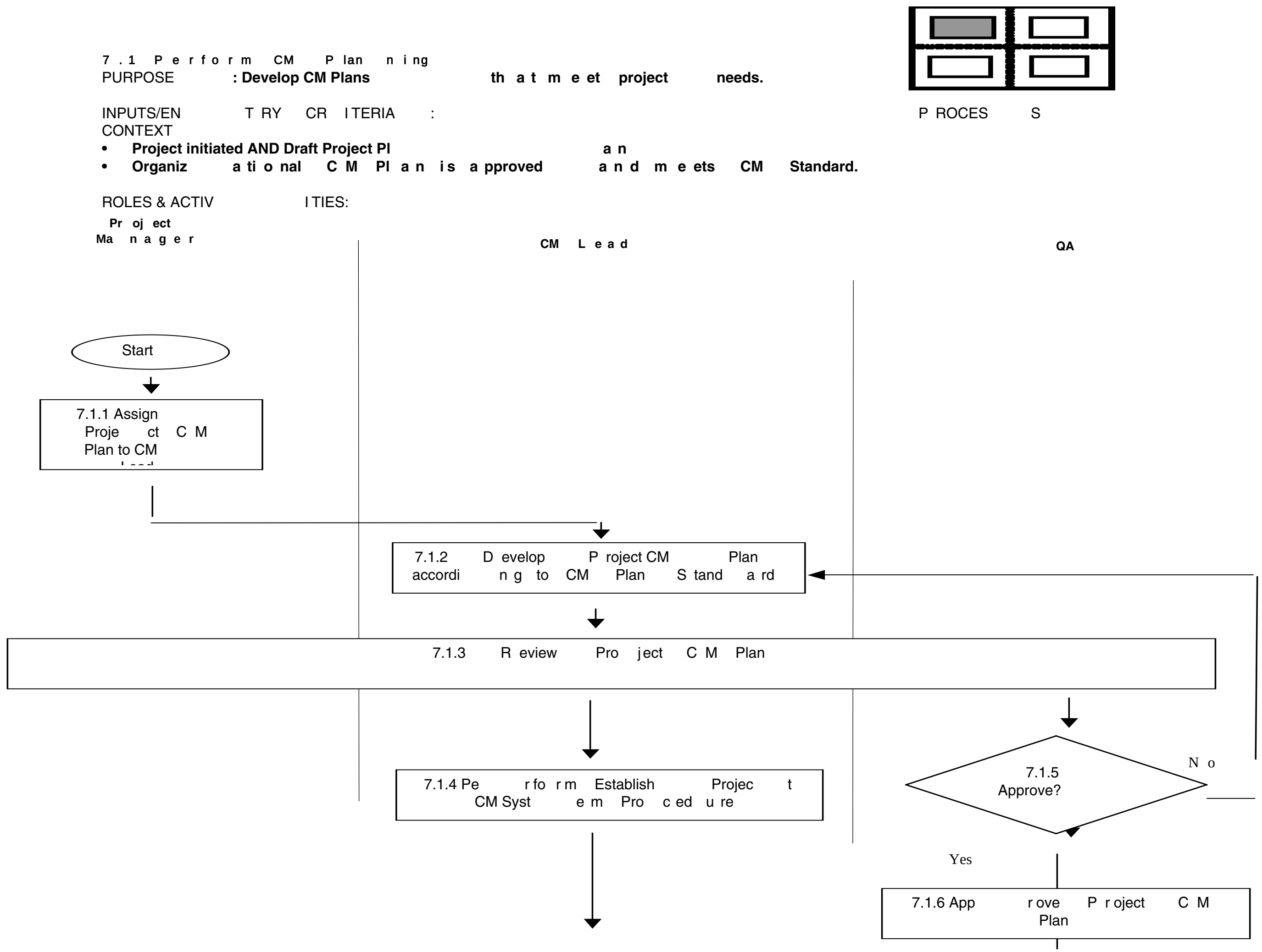
1. Example Lean NASA JPL MGSS CM Process



[Olson 2006a] Olson, Timothy G., “Defining a Lean CM Process at NASA JPL”, Presentation, NDIA CMMI Conference, November 2006.

1. Example Lean CM Process

5 W's on 1 Page in a Process Model

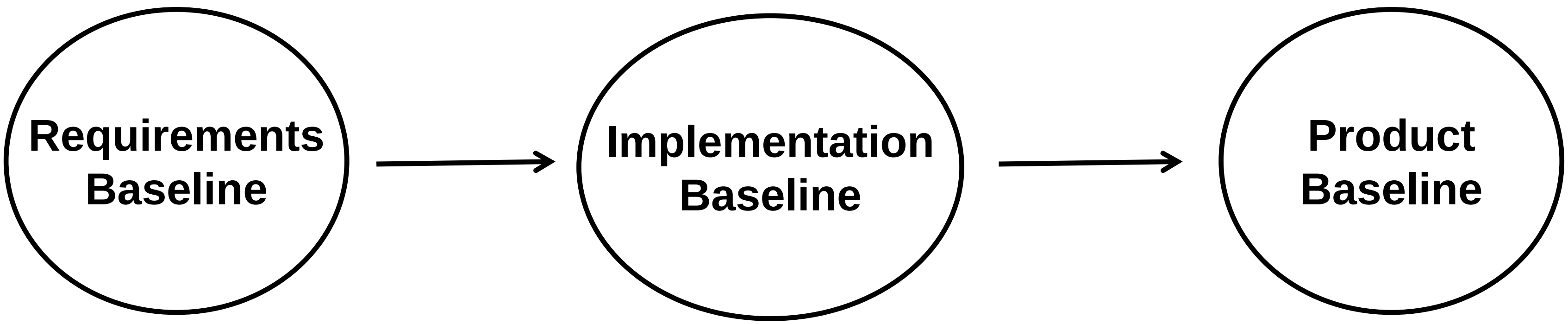


Patent Pending Approach

[Olson 2006a] Olson, Timothy G., "Defining a Lean CM Process at NASA JPL", Presentation, NDIA CMMI Conference, November 2006.

2. Use CM and CM Metrics

Fundamental Baselines



Place the requirements under formal CM and use CCB's to control changes.

<u>Example CM Metrics</u>:

- Number of CRs/PRs (e.g., open vs. closed over time)
- Requirements Volatility (e.g., number of CRs per requirement)

3. Example Requirement Metrics

#	Requirement	Reference (e.g., customer)	Allocation	Stability (H/M/L)	Risk (H/M/L)	Priority (H/M/L)
1	System shall send an RTF FAX	SOW # 10-20.3	Software	H	L	M
2	Aircraft position shall be updated by the Inertial Navigation System (INS) Solution	ORD #2-30-20.3.4.4	Software	M	M	H

4. Documentation Framework

POLICIES
"Laws" or "Principles" that govern operations

STANDARDS
"Operational definitions" & "acceptance criteria"

Guide/Govern

PROCESSES
"What happens over time" to build products

Implemented by

PROCEDURES
"How to" or step by step instructions

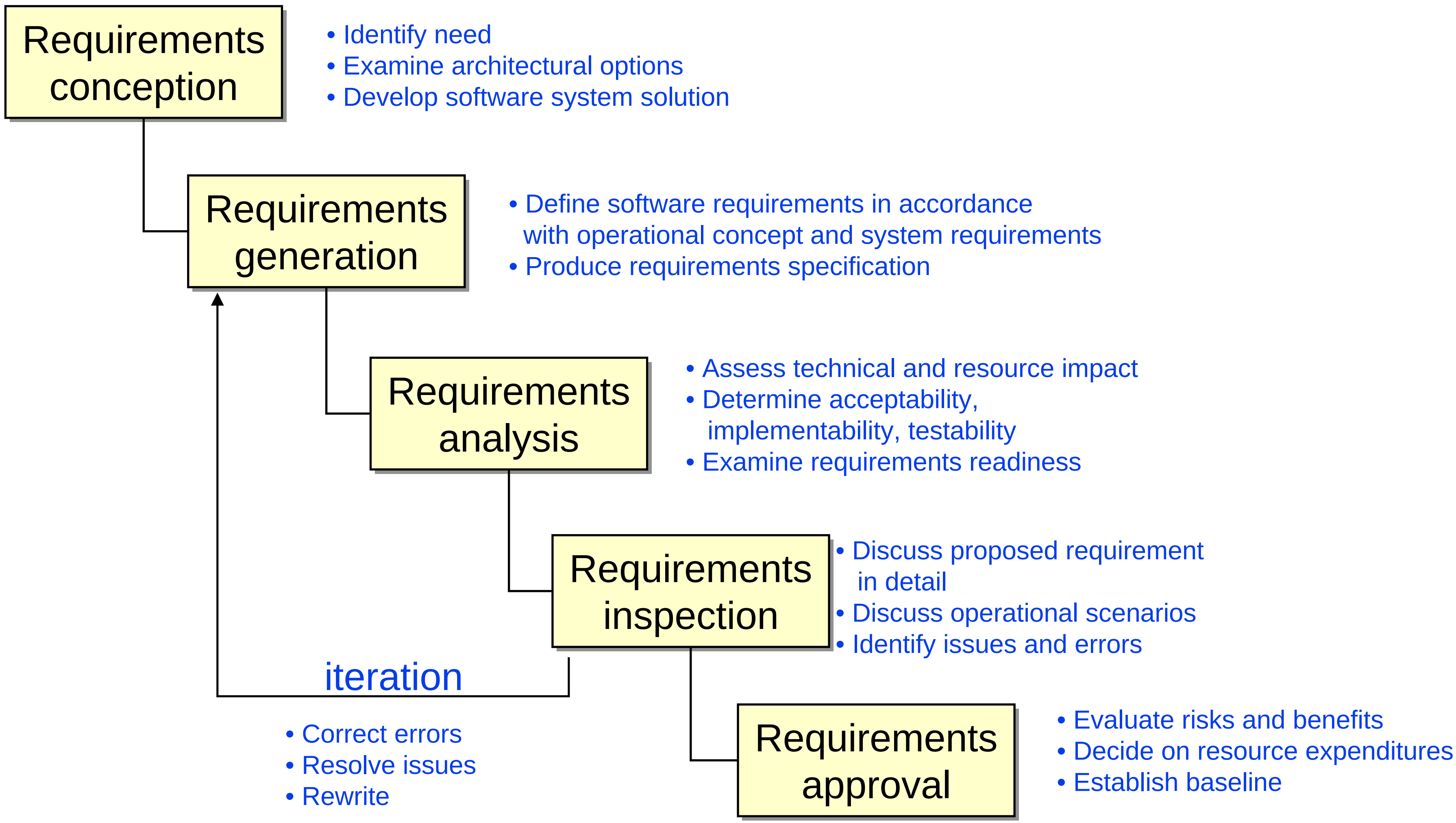
Supported by

TRAINING
Provides the needed knowledge and skills

TOOLS
Supports and automates operations

• Slide adapted from"A Software Process Framework for the SEI Capability Maturity Model", CMU/SEI-94-HB-01

4. Requirements Process - NASA Onboard Shuttle Project



5. IEEE SyRS and SRS Standard Outlines

SyRS

1.0 Introduction
2.0 General System Description
3.0 System Capabilities, Conditions, and Constraints
- 3.1 Physical
- 3.2 System Performance Characteristics
- 3.3 System Security
- 3.4 Information Management
- 3.5 System Operations
- 3.6 Policy and Regulation
- 3.7 System Life Cycle

4.0 System Interfaces

• Adapted from: IEEE Std 1233-1998

SRS

1.0 Introduction
2.0 Overall Description
3.0 Specific Requirements
- 3.1 External Interface Requirements
- 3.2 Functional Requirements
- 3.3 Performance Requirements
- 3.4 Design Constraints
- 3.5 Software System Attributes
- 3.6 Other Requirements

Appendices
Index

• Adapted from: IEEE Std 830-1998

5. Organizing SRS Section 3

SRS Section 3 can be organized by:

- Mode
- User Class
- Object
- Feature
- Stimulus/Response
- Functional Hierarchy
- Multiple organizations

6. Example Requirements Checklist Categories

1. Clarity
2. Completeness
3. Complexity
4. Consistency
5. Constraints
6. Feasibility
7. Functionality/Logic
8. Interfaces
9. Standards
10. TBDs
11. Testability
12. Traceability

Etc.

7. Example Operational Definition

What is a good requirement? When is a requirement defined? Questions like these are difficult to answer without operational definitions.

An operational definition precisely and concisely defines a measurable requirement that states [NASA 96]:

- What it has to do
- How well it has to do it
- Under what conditions it has to do it

7. Example Operational Definition

#	Requirement (What)	Conditions	Upper Limit	Lower limit	Base Measure
1	Report total percentage of students that passed the first test and graduated	Students that pass first test by => 70% score	Calculate Percentage to 3 decimal places	Plus or minus .001	Percent
2	Report total percentage of students that failed the second test and did not graduate	Students that failed second test by < a 70% score	Calculate Percentage to 3 decimal places	Plus or minus .001	Percent

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<u>Juran Model:</u> Customer requirements are written in the customer's language, then translated into the product requirements written in producer's language.

<u>QFD/Juran's Quality Planning Process:</u> Measurable requirements that meet customer needs using a defined process (e.g., House of Quality).

<u>Usage Scenarios/Use Cases/Operational Scenarios:</u> A powerful way to identify requirements based on user needs.

Requirements written in formal languages.

Outline

Why Focus on Requirements?

A Practical Requirements Classification

CMMI Requirements Overview

Practical Approaches for Requirements

Requirement Examples

Some Advanced Approaches

Summary

Summary

The hardest single part of building a system is the requirements.

The top requirements problems are inadequate requirements specifications, changes to requirements, and lack of user input.

Requirements elicitation problems fall into problems of scope, understanding, and volatility.

There are practical strategies that you can use today that will help you address problems with requirements.

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How To Measurably Improve Your Requirements

NDIA Systems Engineering Conference
October 2007

Timothy G. Olson, President
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Stochastics Working Group

Introduction

- The CAE/Simulation market continues to see rapid and sustained growth
- Two recent innovations within the Analysis & Simulation community are:
  1. The low cost of compute capacity
  2. The ever increasing sophistication of simulation software
- The use of stochastics has been validated in the commercial automotive crash and test applications
- The use of stochastics is applicable across engineering disciplines

These trends are continuing and we can now expect to mimic true lifelike analysis through realistic and verifiable iterative analysis.

NAFEMS Objectives

NAFEMS mission is to act as a trusted source and a collaborative resource for the best engineering modeling, simulation and analysis practices in the development of safe, reliable, and affordable products. Its focus is to champion and improve best practices, to promote and enrich educational opportunities aligned with the rapidly-advancing technologies, and to advance the productivity and quality of virtual product development processes.

Specific objectives of NAFEMS are to:

- Promote **COLLABORATION** within the international engineering analysis and simulation community,
- Stimulate **INNOVATION** via transfer of knowledge in the use of advanced scientific, engineering and computing technologies,
- Maximize **PRODUCTIVITY** through improved best practices used in product development engineering processes,
- Implant **QUALITY** in the methods and techniques exploited by virtual product development processes.

NAFEMS is a not-for-profit membership association of nearly **800 companies** from all over the world.

NAFEMS Stochastics Working Group

- SWG Purpose:
  - Promote the adoption and further development of practical applications to meet the Value Propositions
  - Give unique insight and perspective into the area of stochastics.
  - Collaborate on recent developments
  - Share breakthrough technologies

NAFEMS Stochastics Working Group

- Mix of industrialists, consultants, vendors, and academia:
  - Provide recommendations to advance the user community
  - Share breakthrough technology to the dedicated community
  - Provide support to the SWGSC
  - Publish whitepapers
  - Focus on the user community

NAFEMS Stochastics Working Group Steering Committee (SWGSC)

- Based on a core team of 9 members:
  - Proactively represent the working group
  - Provide recommendations to advance the user community
  - Share breakthrough technology to the dedicated community
  - Publish whitepapers (with SWG support)
- End-user driven

SWG Steering Committee

Members:

- Michel Klein – ESA
- Sadek Rahman – Daimler Chrysler
- Tsuyoski Yasuki – Toyota
- Alexandar Karl – Rolls-Royce
- Raj Rajagopal – Pratt & Whitney Rocketdyne
- Kazuhiro Iijima – Nissan
- Mats Larsson – SAAB
- Rodney Dreisbach – Boeing
- Mary Fortier – General Motors

simulating REALITY™

Simulation-Supported Decision Making

Gene Allen

Director, Collaborative Development

MSC Software Corporation

Simulation – A Tool for Decision Making

- Quickly Identify and Understand How a Product Functions:
  - What are the major variables driving functionality?
  - What are the combinations of variables that lead to problems in complex systems?
- Ability Exists Today
  - Due to advances in compute capability

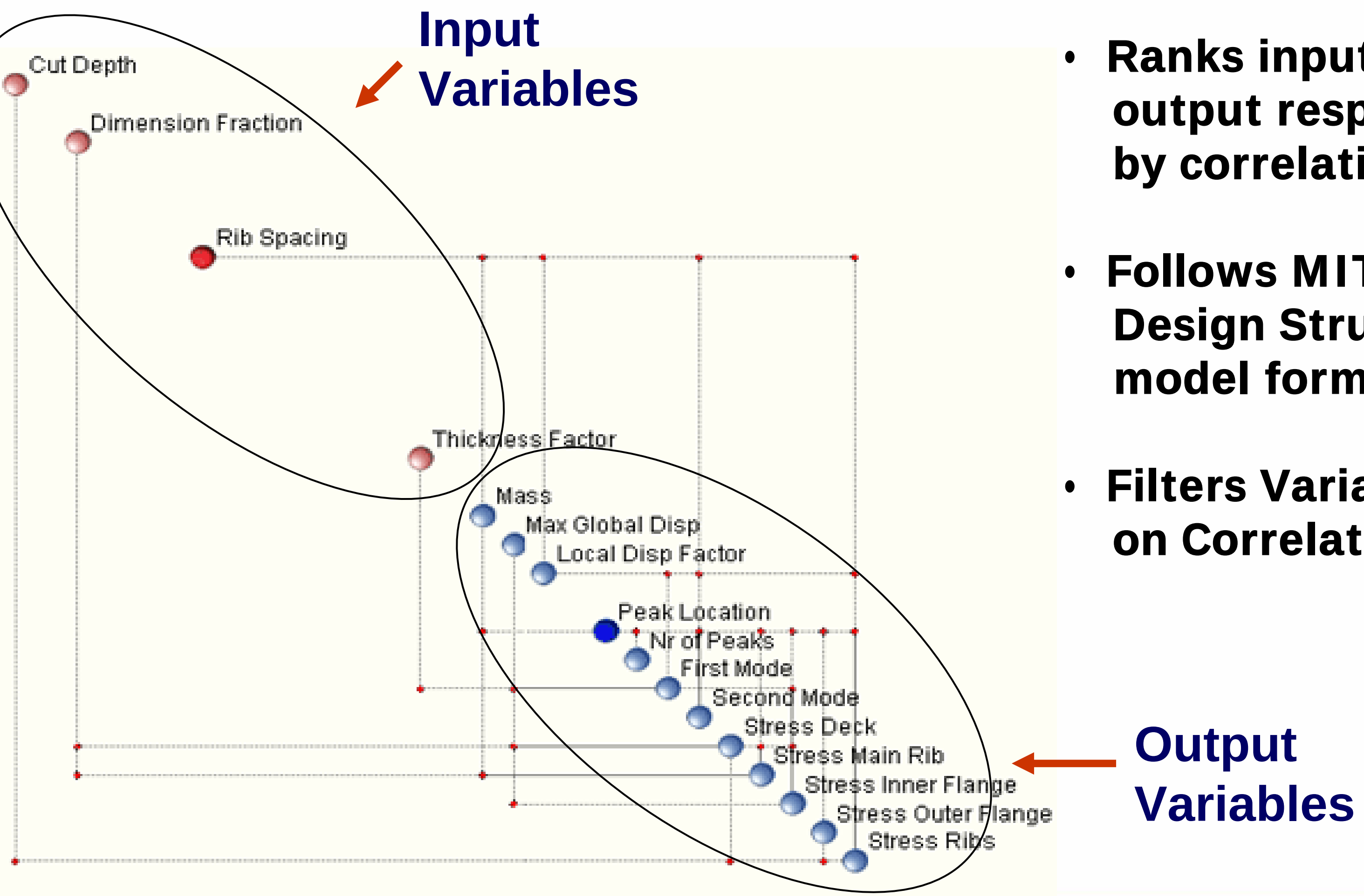
Decision Maps

Generation of Decision Maps

Decision Map – a 2-D view correlating Results generated from Monte Carlo Analysis

- **Incorporates Variability and Uncertainty**
- **Updated Latin Hypercube sampling**
- **Independent of the Number of Variables**
- **Results with 100 runs**
- **Does Not Violate Physics**
  - **No assumptions of continuity**
- **“Not elegant, only gives the right answers.”**

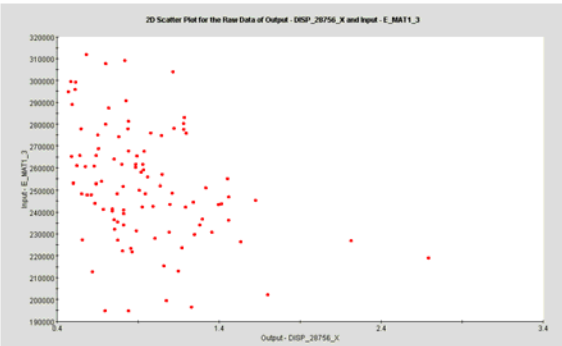
Decision Maps to Understand Cause & Effect

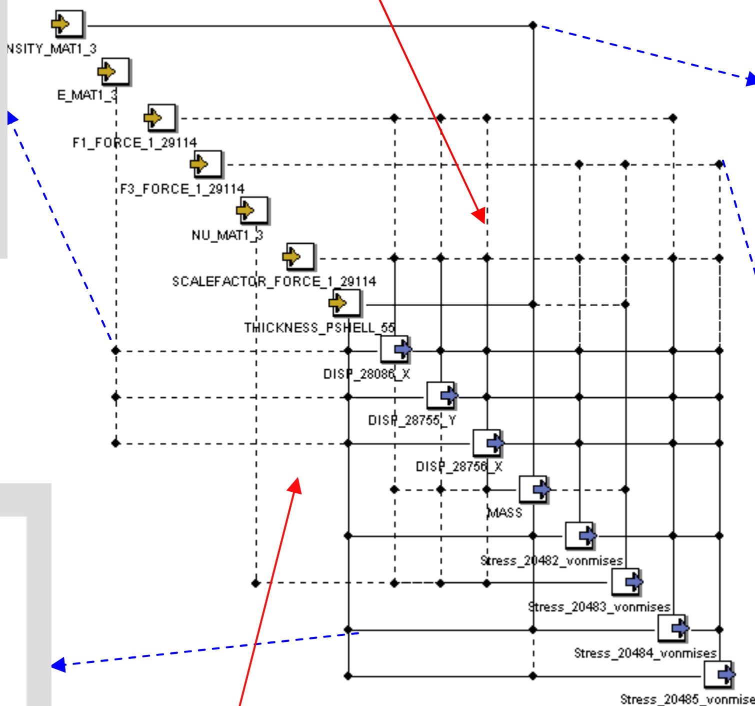


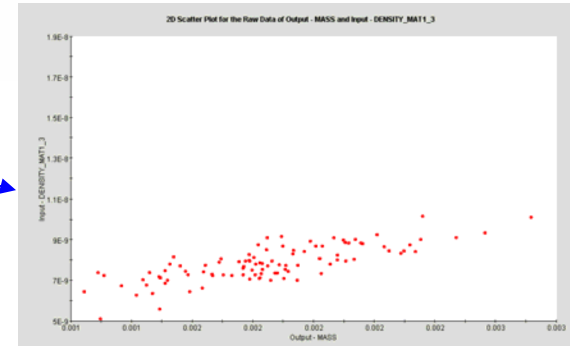
- Ranks input variables and output responses by correlation level
- Follows MIT-developed Design Structure Matrix model format
- Filters Variables Based on Correlation Level

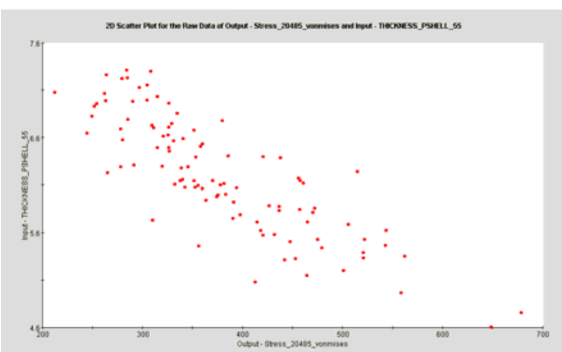
A Decision Map

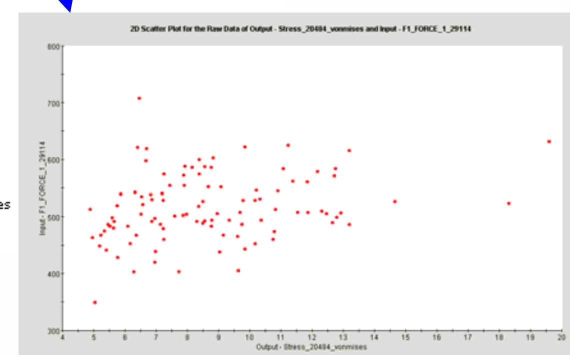
Upper right –
positive correlation





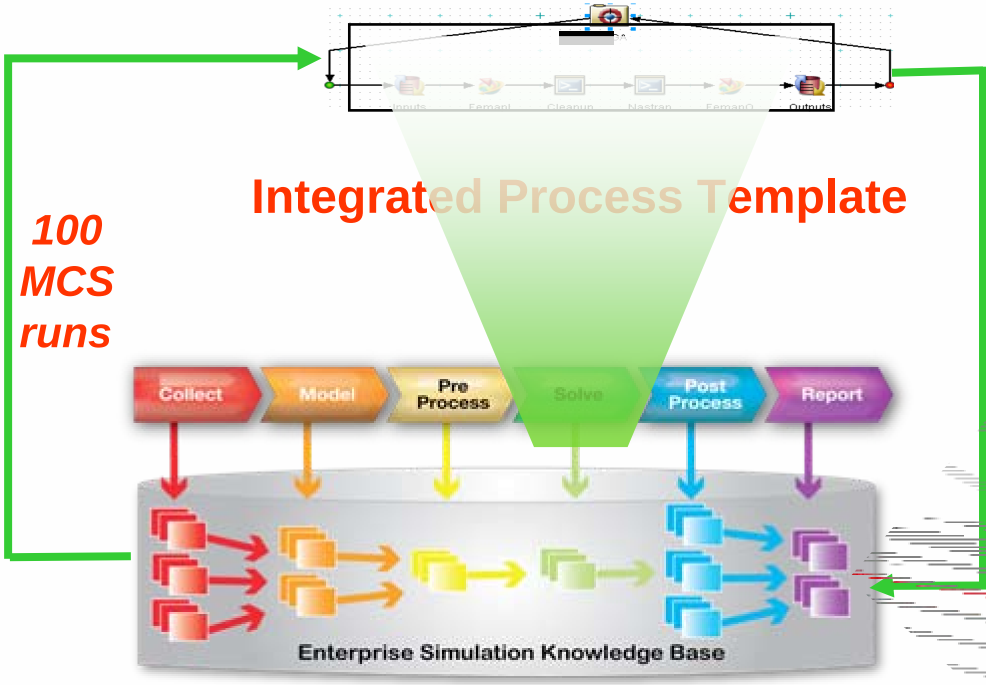


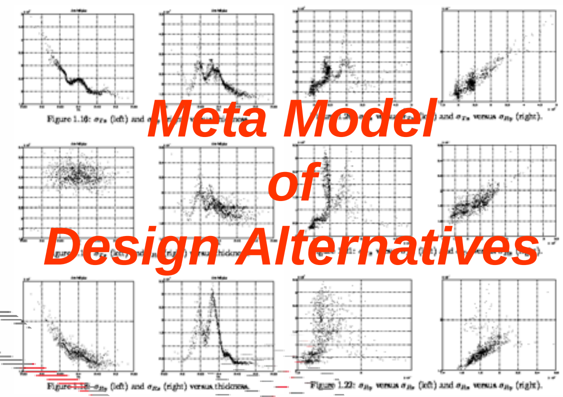


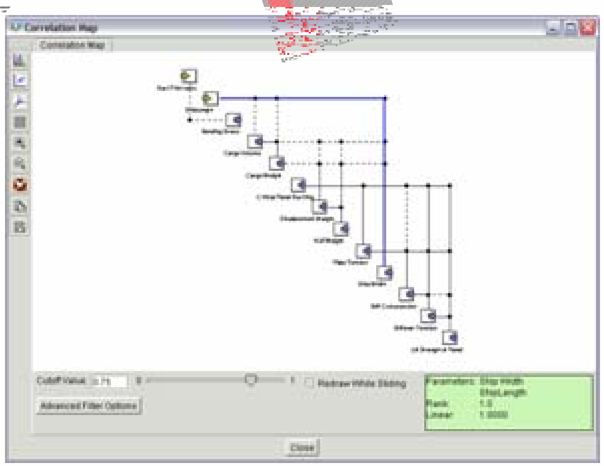


Lower left –
negative correlation

Generation of Decision Maps





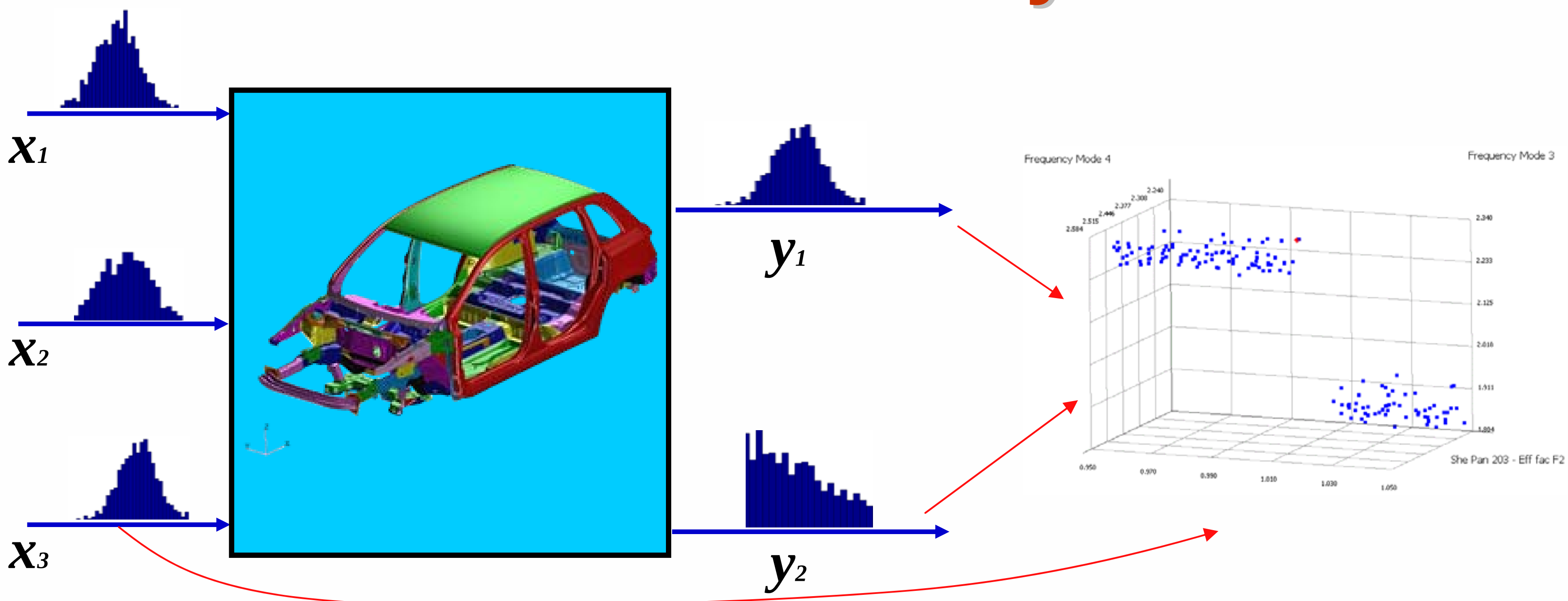


Correlation Map:

- Includes All Results

- Highlights Key Variables

Monte Carlo Analysis



Sources of Variability

- **Material Properties**
- **Loads**
- **Boundary and initial conditions**
- **Geometry imperfections**
- **Assembly imperfections**
- **Solver**
- **Computer (round-off, truncation, etc.)**
- **Engineer (choice of element type, algorithm, mesh band-width, etc.)**

Solution:

Establish tolerances for the input and design variables.

Measure the system's response in statistical terms.

The Fundamental Problem …

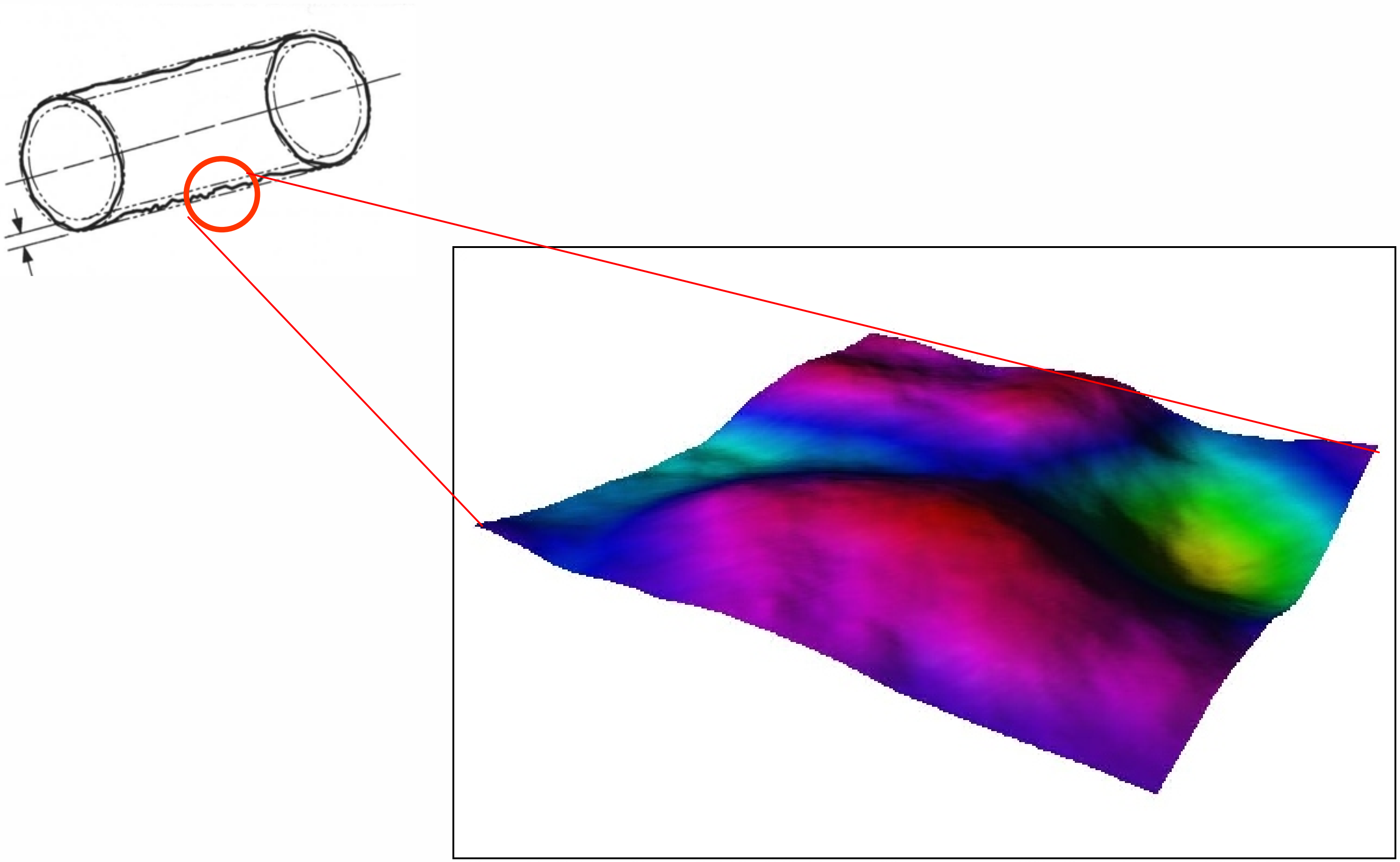
Structural Material Scatter

MATERIAL	CHARACTERISTIC	CV
Metallic	Rupture	8-15%
	Buckling	14%
Carbon Fiber	Rupture	10-17%
Screw, Rivet, Welding	Rupture	8%
Bonding	Adhesive strength	12-16%
	Metal/metal	8-13%
Honeycomb	Tension	16%
	Shear, compression	10%
	Face wrinkling	8%
Inserts	Axial loading	12%
Thermal protection (AQ60)	In-plane tension	12-24%
	In-plane compression	15-20%

Source: Klein, M., Schueller, G.I., et.al.,Probabilistic Approach to Structural Factors of Safety in Aerospace, Proceedings of the CNES Spacecraft Structures and Mechanical Testing Conference, Paris, June 1994, Cepadues Edition, Toulouse, 1994.

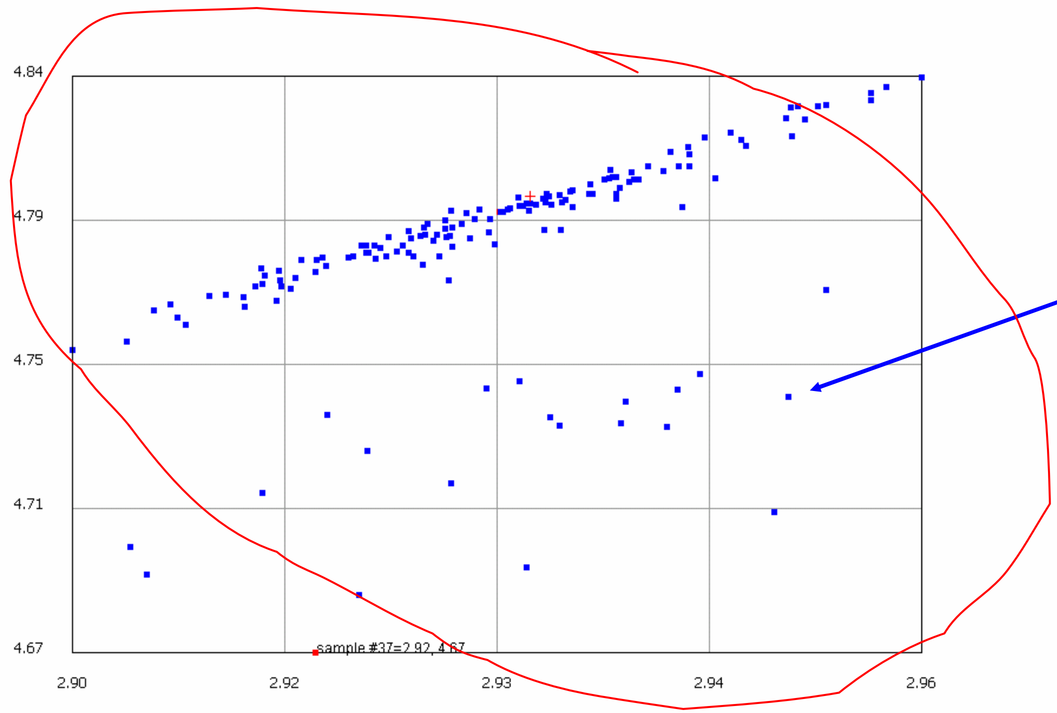
The Deception of Precise Geometry

Geometry imperfections should be described as stochastic fields.



Monte Carlo Results show Reality

Collection of computer runs = **Simulation**



Single computer run = **Analysis**

Understanding the physics of a phenomenon is equivalent to the understanding of the topology and structure of these clouds.

Understanding MCS Results

- Simulation generates a large amount of data.
  - A typical simulation run requires around 100 solver executions.
  - Each combination of hundreds to thousands of variables produces a point cloud. In each cloud:
    - POSITION provides information on PERFORMANCE
    - SCATTER represents QUALITY
    - SHAPE represents ROBUSTNESS

KEY:

- REDUCE the Multi-Dimensional Cloud to EASILY UNDERSTOOD INFORMATION
  - Condense into a DECISION MAP
  - Variables are sorted by the strength of their relationship

Monte Carlo Simulation Results

Number of 2D Views of Results = Sum of all integers from 1 to (Number of Variables -1)

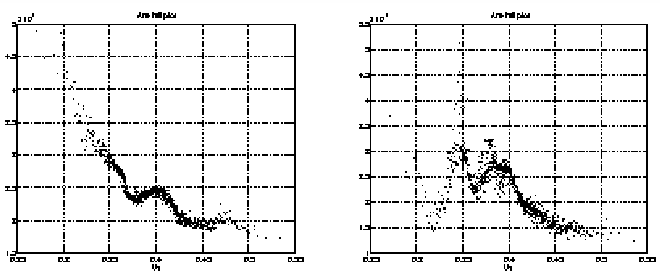


Figure 1.16: σ_{Tx} (left) and σ_{Ty} (right) versus thickness.

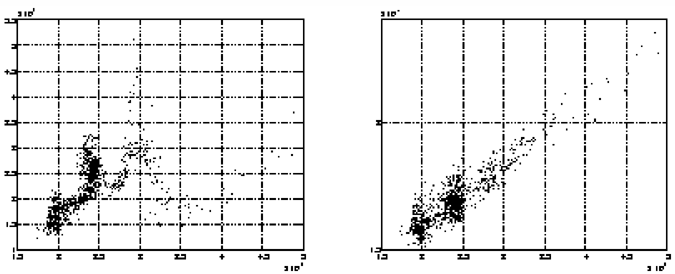
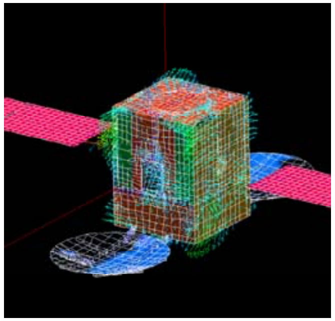


Figure 1.20: σ_{Tx} versus σ_{Ty} (left) and σ_{Tx} versus σ_{Ry} (right).



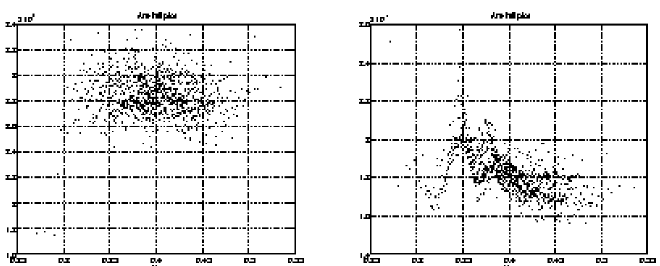


Figure 1.17: σ_{Tz} (left) and σ_{Rx} (right) versus thickness.

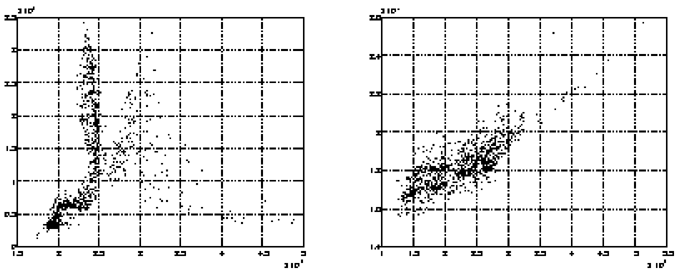


Figure 1.21: σ_{Tx} versus σ_{Rz} (left) and σ_{Ty} versus σ_{Rz} (right).

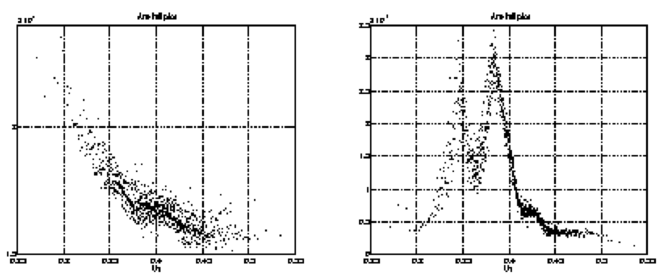


Figure 1.18: σ_{Ry} (left) and σ_{Rz} (right) versus thickness.

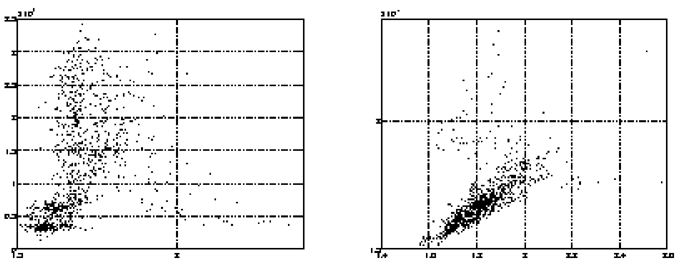


Figure 1.22: σ_{Ry} versus σ_{Rz} (left) and σ_{Rx} versus σ_{Ry} (right).

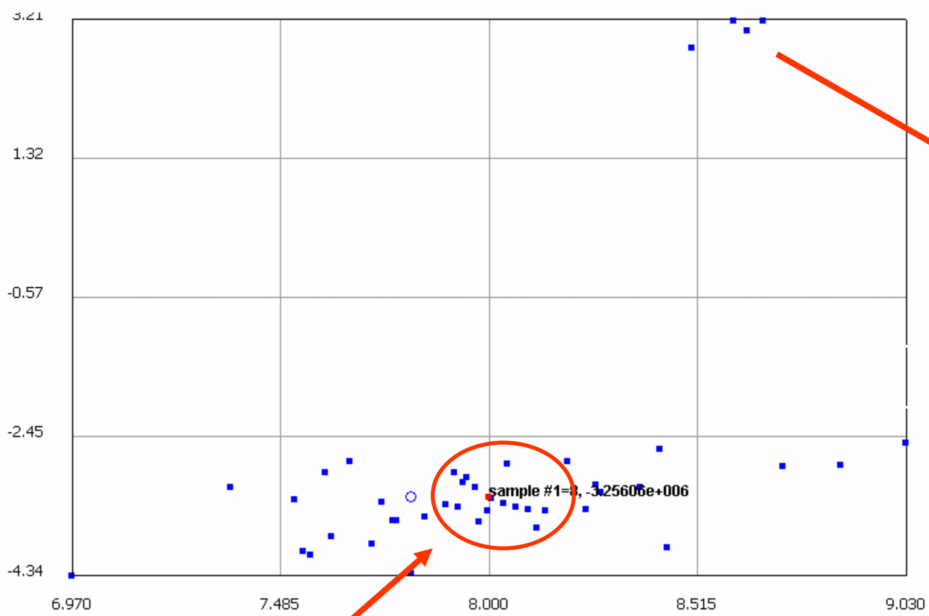
12 of the 78 2D views that resulted from a simulation with 6 outputs from a scan of 7 inputs with uniform distributions.

Decision Maps: Understanding Cause and Effect

- Displays condensed information from hundreds of analysis runs.
- Decision Map = Structured Information = Knowledge
- A Decision Map helps an engineer:
  - Understand how a system works.
    - How information flows within the system.
    - how variables and components correlate.
  - Make decisions on how a design may be improved.
    - Identify dominant design variables.
    - Use as input for stochastic design improvement.
  - Find the weak points in a system.
  - Find redundancies in a design.
  - Identify rules that govern the performance ("if A and B then C").

There are NO algorithms to learn. The engineer concentrates on engineering, not on numerical analysis.

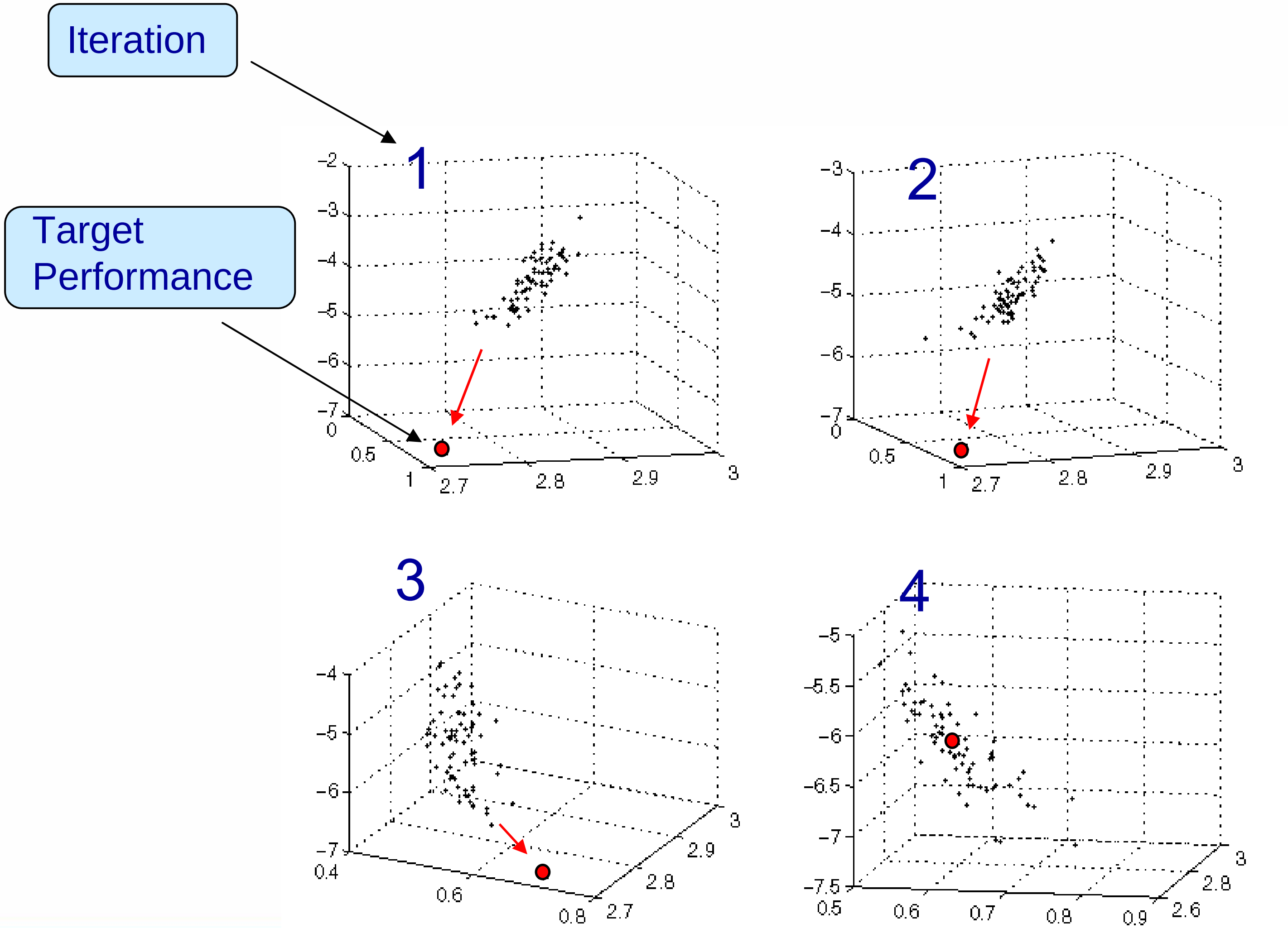
Outlier Identification



Most likely behavior

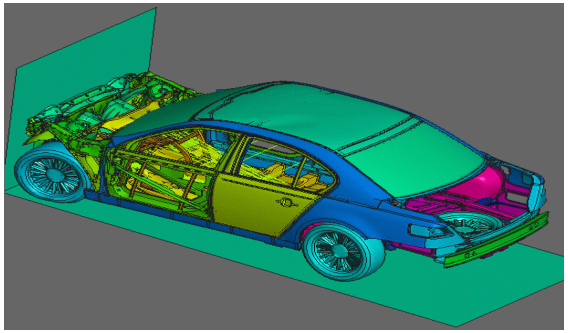
Outliers: may be dangerous:
- System Failure
- Mission Failure

Design Improvement Process

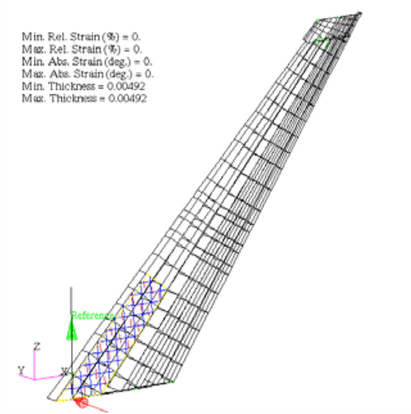


APPLICATIONS

- Automotive and Aerospace companies have continued to expand use of process since 1997
- BMW, Audi, Toyota, Mecedes, Nissan and Jaguar have expanded Computer Clusters for Stochastic Car Crash Simulation taking 10's of pounds from car model designs.
- Aerospace companies applying to improve aerospace designs. Alenia reduced weight of new commercial airliner tail by 6%.



Courtesy of BMW AG



Courtesy, Alenia Aeronautica

Process for Decision Support

- Model a multi-disciplinary design-analysis process
- Randomize the process model
- Run Monte Carlo simulation of the model
- Process Results
  - Correlation Maps showing Cause and Effect
  - Outlier identification showing anomalies
  - Direction for Design Improvement

Correlation Maps - Filter Complexity while Modeling Reality

- Identify what influences functionality
- Address Uncertainty and Variation
  - Provides credibility in modeling & simulation
  - Results clouds represent what is possible
- Easy to use
  - No methods or algorithms to learn
- Reduces risk through better engineering
  - Takes all inputs into account vice using initial assumptions
- Changing the general engineering process

10th Annual NDIA Science & Engineering / DoD Tech Expo
"Reducing Technology Risk in Acquisition Programs"

Testing Concept of Operations (CONOPS) in DoD's Net-Centric Environment

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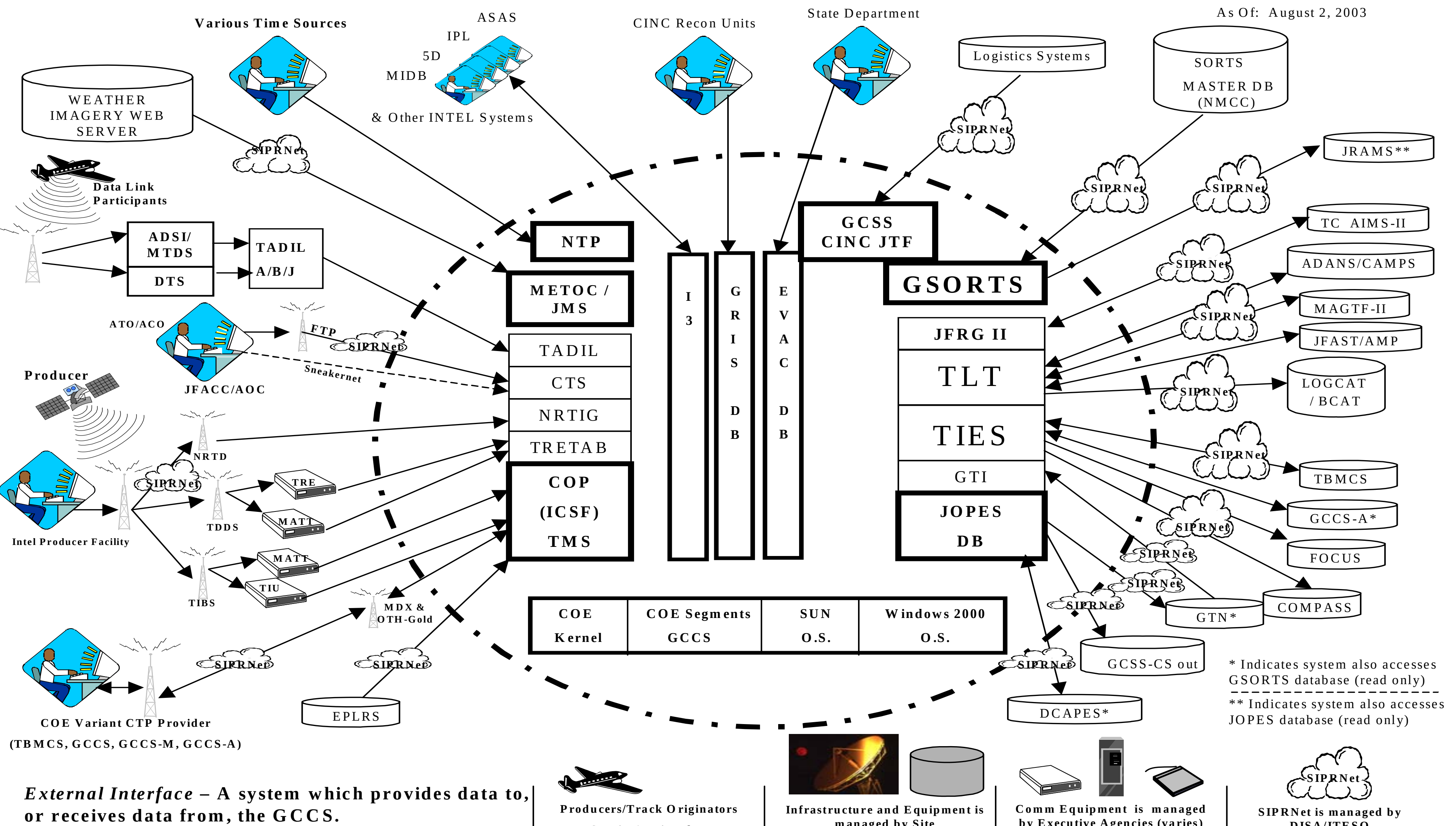
SCRA
Collaborating To Advance Technology

October 22-26, 2007

We get lost in diagrams like this. . . don't we?

GCCS-J 4.x External Interface Architecture



Basic Doctrinal Requirements

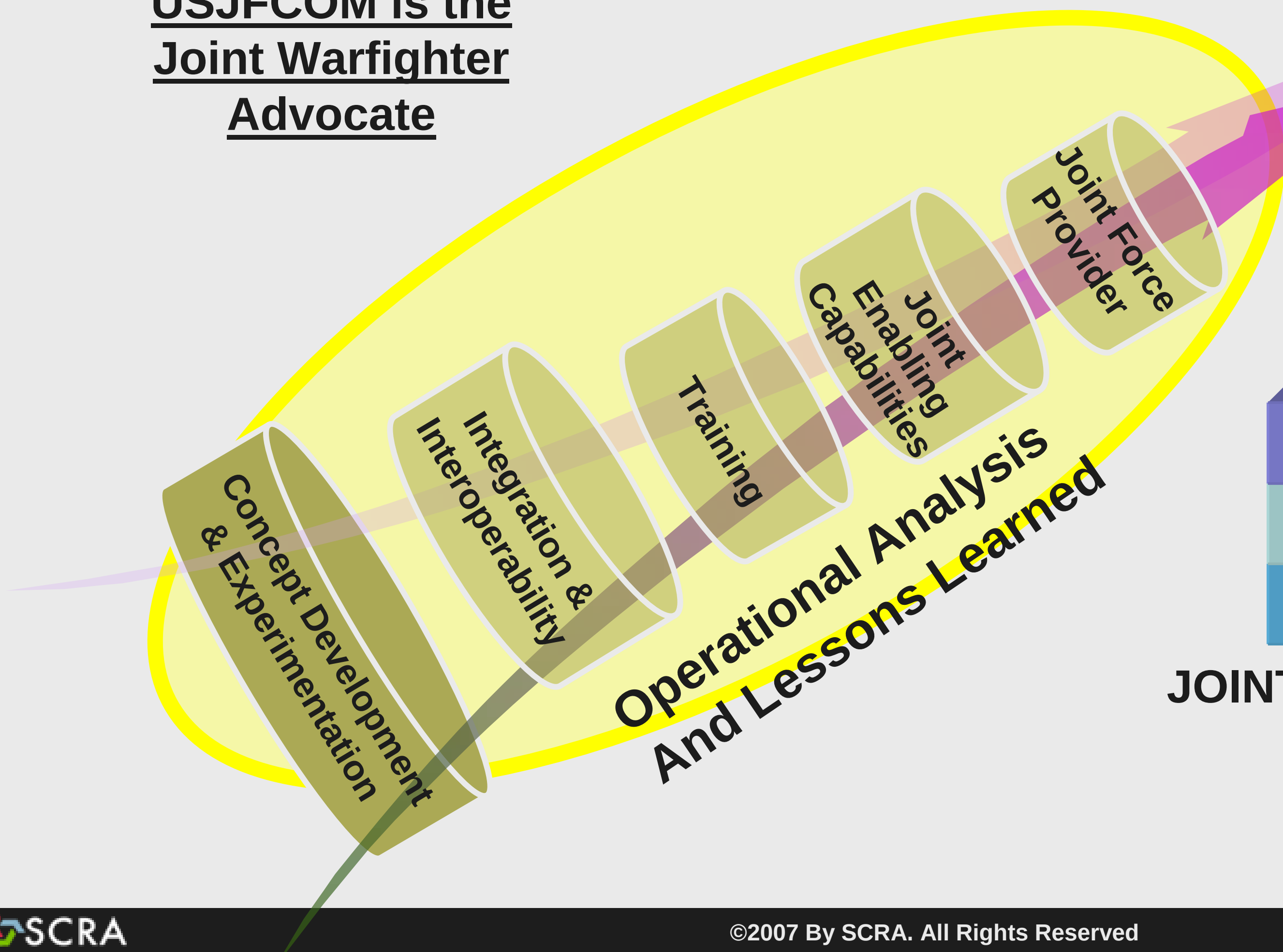
DoD's responsibility is the management of <u>violence</u>. → **Regardless the of <u>Technology</u>**

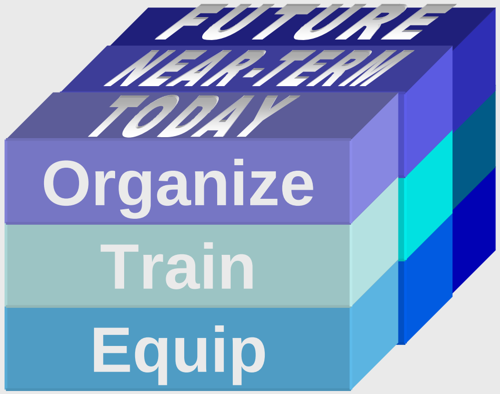
Principles of War

- **Objective**
  Clearly defined, decisive and attainable objective. Each operation must contribute to the ultimate strategic aim. ...
- **Offensive**
  Seize, retain, & exploit the common objectives. Means to maintain freedom of action & achieve decisive results.
- **Mass**
  Synchronizing all the elements of combat power. Mass the effects not necessarily the forces.
- **Economy of Force**
  No part of the force should ever be left without a purpose
- **Maneuver**
  Movement of forces in relation to the enemy to gain positional advantage. Continually pose new problems for the enemy by rendering his actions ineffective & eventually defeating him.
- **Unity of Command**
  For every objective, seek unity of command and unity of effort. Unity of command means that all the forces are under one responsible commander
- **Security**
  Never permit the enemy to acquire unexpected advantage. Protecting the force increases friendly combat power..
- **Surprise**
  Strike the enemy at a time or place or in a manner for which he is unprepared
- **Simplicity**
  Prepare clear, uncomplicated plans and concise orders to ensure thorough understanding effectiveness

What USJFCOM Does to Support the Joint War

First and foremost USJFCOM is the Joint Warfighter Advocate

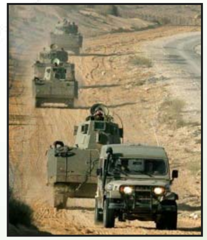




JOINT CAPABLE FORCES

Major Mission Command & Control (C2) Capabilities Areas

FORCE PROJECTION
Joint Operation Planning
& Execution System (JOPES)



FORCE EMPLOYMENT
Air, Land, and Sea Operations
CAS Planning and Execution

SITUATIONAL AWARENESS
Common Operational Picture (COP)

FORCE READINESS
Readiness Assessment System (RAS)

Global Status of Resources and Training System (GSORTS)

FORCE PROTECTION
Early Warning and Integrated Air and Missile Defense

INTELLIGENCE
Integrated Imagery Intel (I3)

DoD's Approach to Developing Net Centricity

Program Decision Memorandum (PDM) III, December 20, 2005, Tasked the Assistant SecDef for Networks & Information Integration / DoD Chief Information Officer (ASD(NII) / DoD CIO….
"To accelerate the provisioning & adoption of Core Enterprise Services (CES) across DoD.

In commercial industry speak, that means to start developing a System Oriented Architecture (SOA) approach for C2.

Perspective

The DoD must continue to evaluate/assess technology's impact on the current war. And quickly adopt approaches that increase our combat capabilities

- Emerging technologies, like SOA and innovative CONOPS must accelerate, <u>together</u>
- Viable technologies must be rapidly integrated into current C2 practices, allied operations, training, and doctrine for **maximum** effectiveness
- Warfighter needs are dynamic, our coalition arrangements are unique, and the "funding-requirement-acquisition" process is unacceptable in the 'immediate' for the soldier on the patrol

We believe that Net-Centric Environment "e.g. SOA approach" is the next principal mechanism for enhanced Command Capability of Joint C2.

Changing Business Model

Where we are		Where we need to be
Familiar		Less familiar
What we use	*FOCUS*	What we use and how we use it
Technology affects on system capability	*SOLUTION*	Technology + method + people affect on operational capability
Developers' perspective	*PERSPECTIVES*	Warfighter perspective
Hardware and software must be developed together	*CENTRAL RULE or CONCEPT*	Materiel and non-materiel must be developed together
SoS assessment - OT&E focus on the system	*APPROACH*	MCP assessment - Holistic focus on all components
System centric	*CENTRICITY*	Capability centric (Warrior)

Focus on Joint Warfighter's urgent operational need -- solution providers must forge a single 'integrated' enterprise to reduce risk in satisfaction of that need.

Changing the Business Model Requires:

(1) Willingness to work together to leverage each others core competencies

(2) Focus on Joint Warfighter as central driver – solution need originator and evaluator

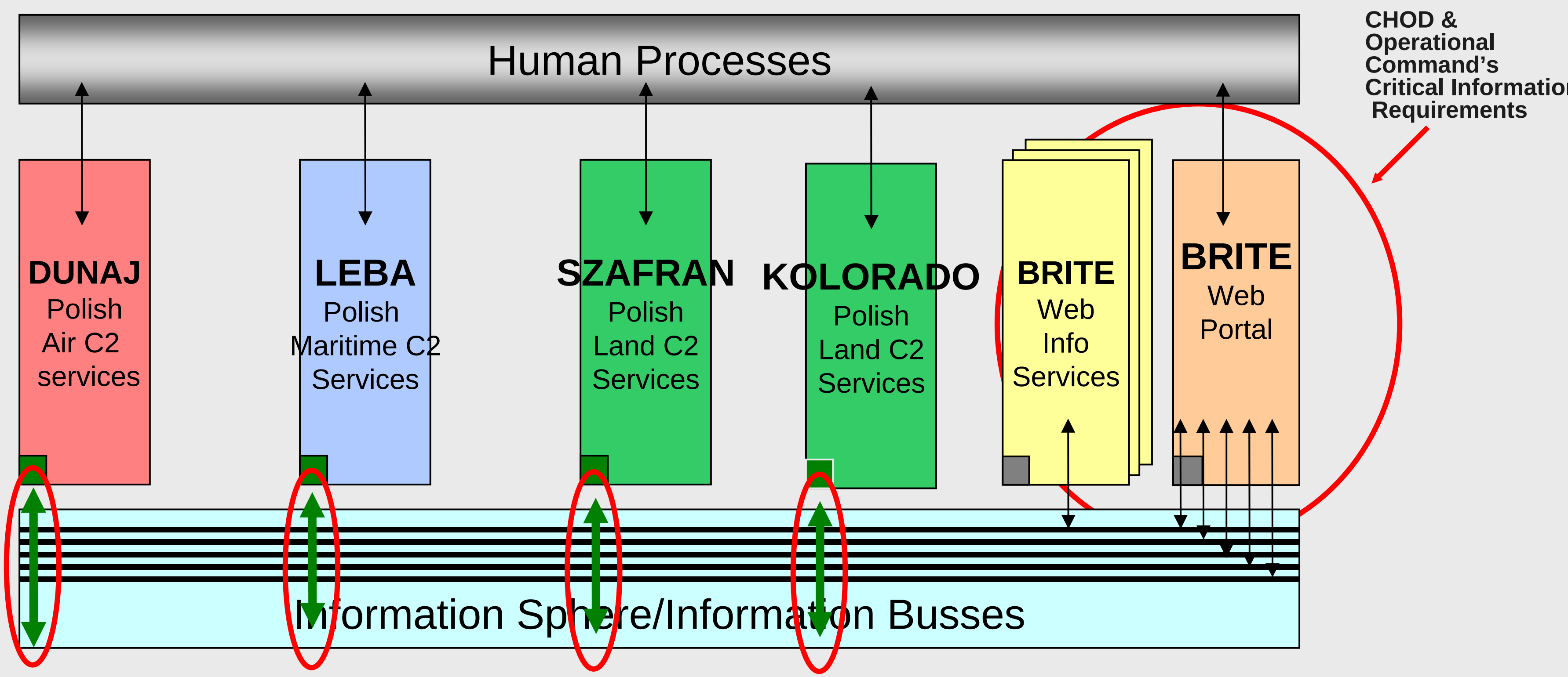
(3) Commitment to providing meaningful services rather than inflexible "products"

Poland's Case Study

- TRANSFORMATION EFFORTS:
  - *Moving away from a Soviet based system*
  - *Moving to a professional as apposed to a conscript based force*
  - *Moving to a capitalistic based economic model*
  - *Moving to asymmetric warfare*
  - *Moving to a net-centric combat capable force*

- At the request of Poland's Chief of Defense (CHOD), a combined NATO and USJFCOM, Poland's Military staff, plus Industry and Academia constructed a near term Common Operating Picture (COP).
- Constructed a near term SOA environment to integrate Poland's Air, Land and Sea into a combined Common Operational Picture.
- Supported Poland's role as a NATO member & US strategic partner

Poland's Case Study

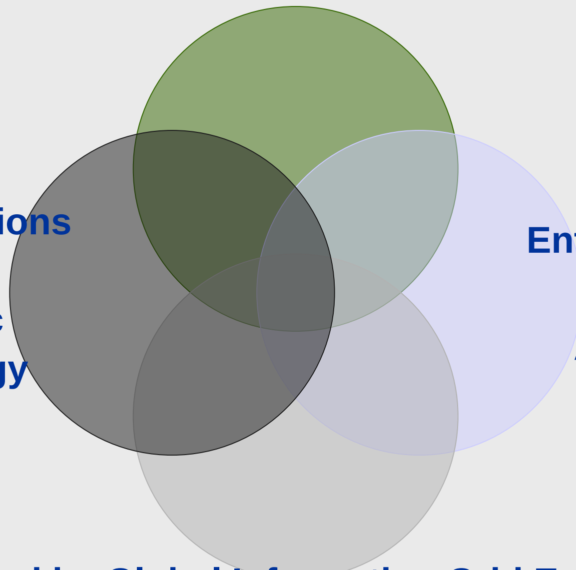


BRITE interface incorporated in every system

Automatic discovery add-ons

BRITE = Baseline for Rapid Iterative Transformational Experimentation

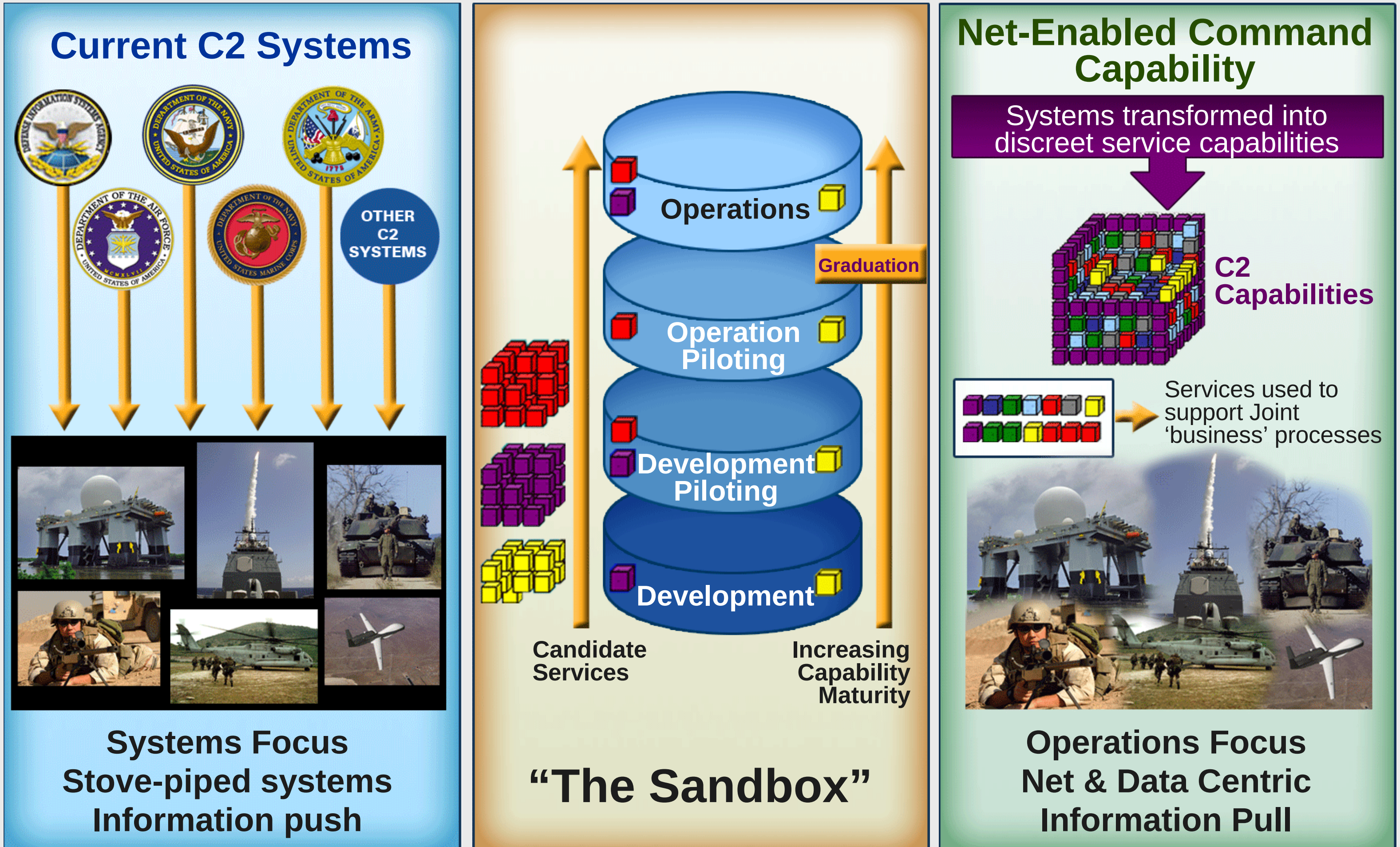
DoD's Web Services Characteristic



These web systems and services will have a unique combination of characteristics that differentiate them from more conventional legacy client server applications. In particular, they tend to include:

- Architecture places data at the center of its design: Enterprise Resource Pattern (ERP) & Enterprise Service Bus (ESB)
- ERP standardizes access to any C2 domain object (APIs)
- ESB publishes messages based on an event/trigger
- Rapidly changing technologies, e.g. more actors, platforms, networks, and services not applications

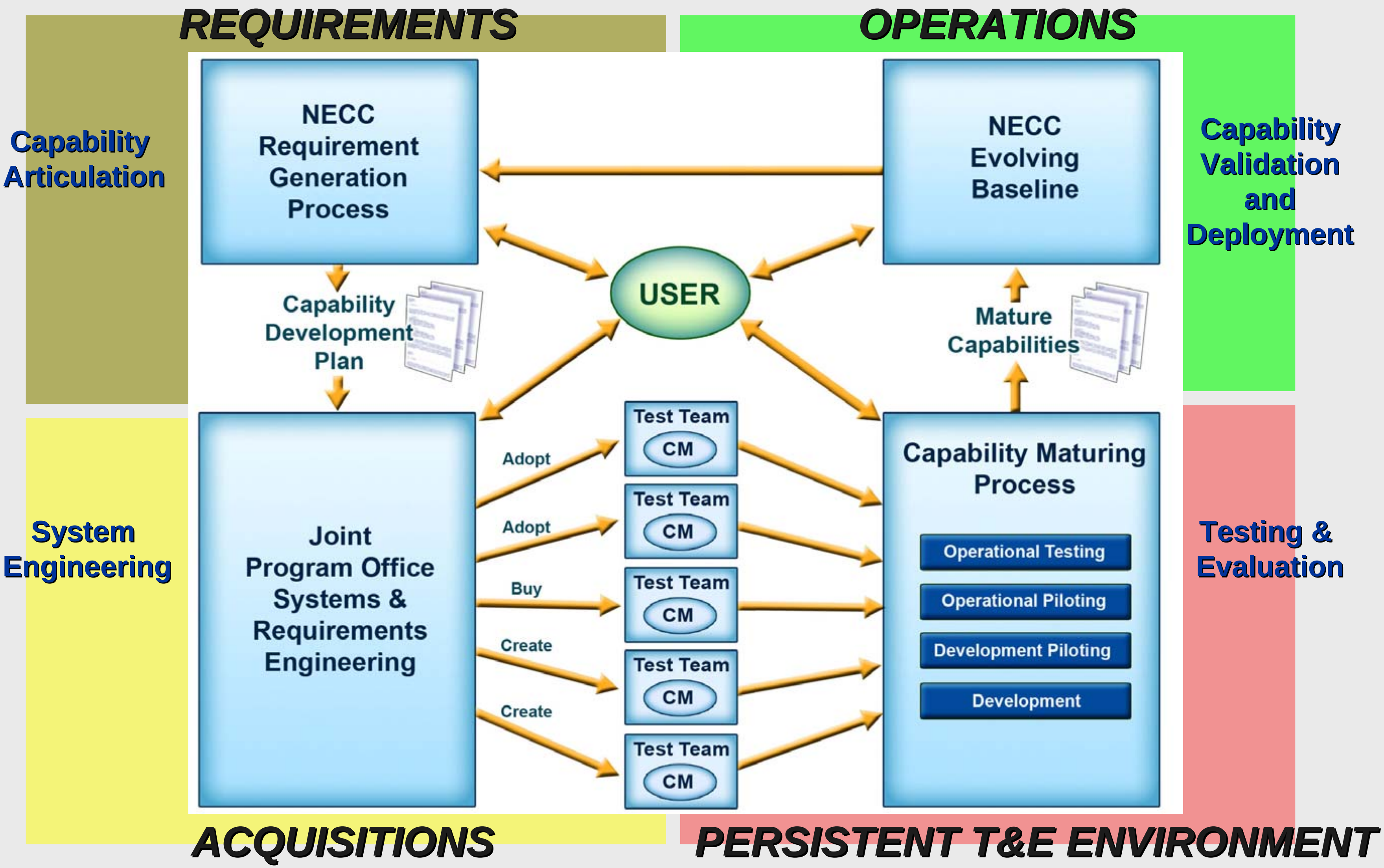
Joint Capability of Net-Enabled Command Capability (NECC)



Joint Warfighters Command and Control Need Driven

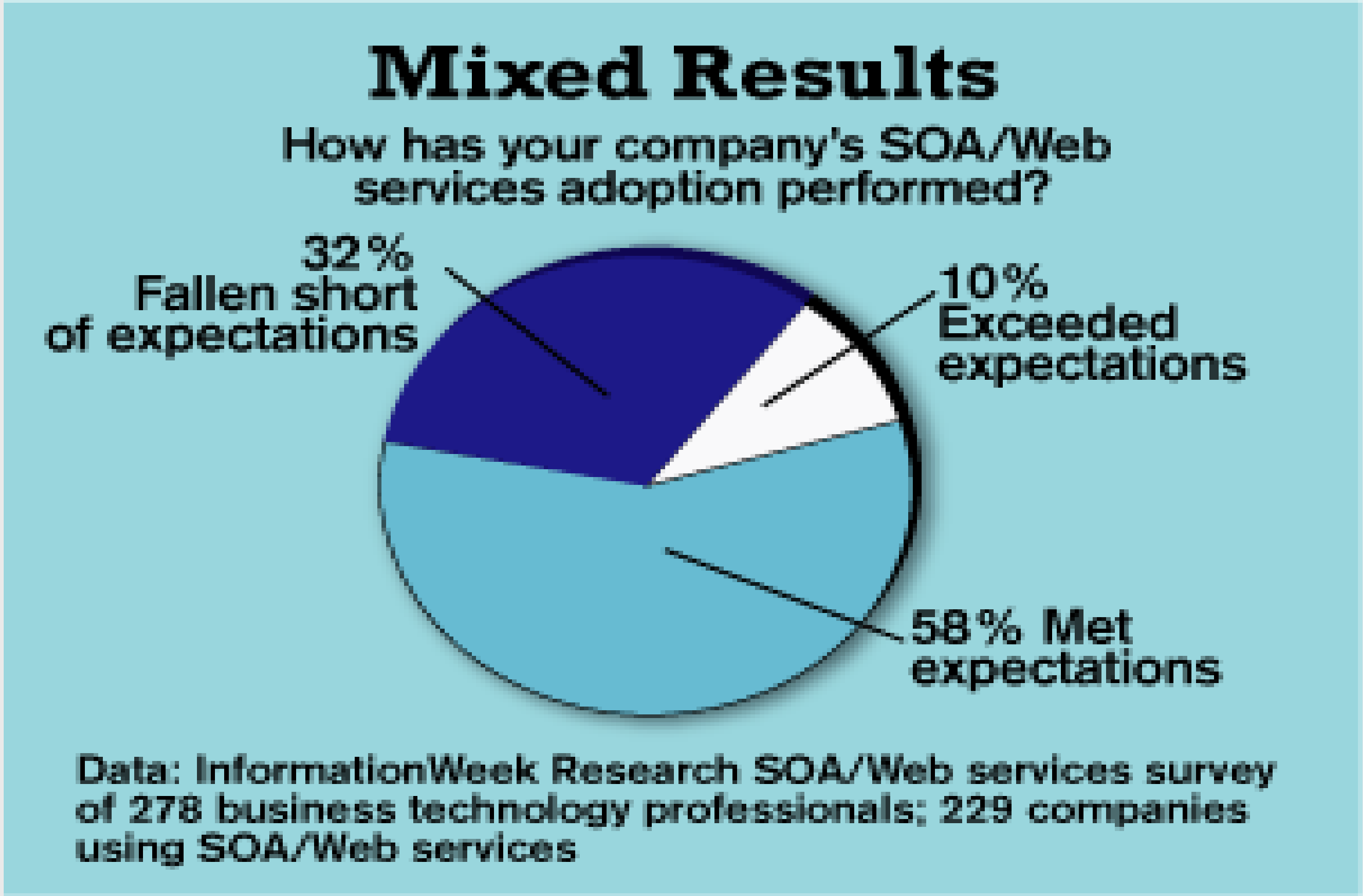
With the net centric approach, user engagement occurs in the “sandbox” during the combined evaluation referred to as the “piloting” events.

Integrated Enterprise Process



Challenge/Approach

Industries Mixed Results



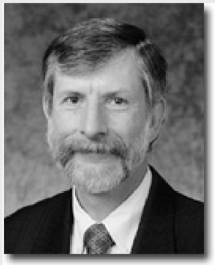
Challenge/Approach

David Linthicum

Top 5 Mistakes w/ SOA,

1. Not enough trained IT/SOA architects to put on the problem.
2. “Manage by Magazine” approach to SOA.
3. Don’t understand the unique nature of their problem domains.
4. Treat SOA as a project, not a journey.
5. Unable to define the value.

Oh, by the way: David said,
“I Actively tracks 120 different
SOA standards
20% to 30% are duplicative
At any one point in time.”



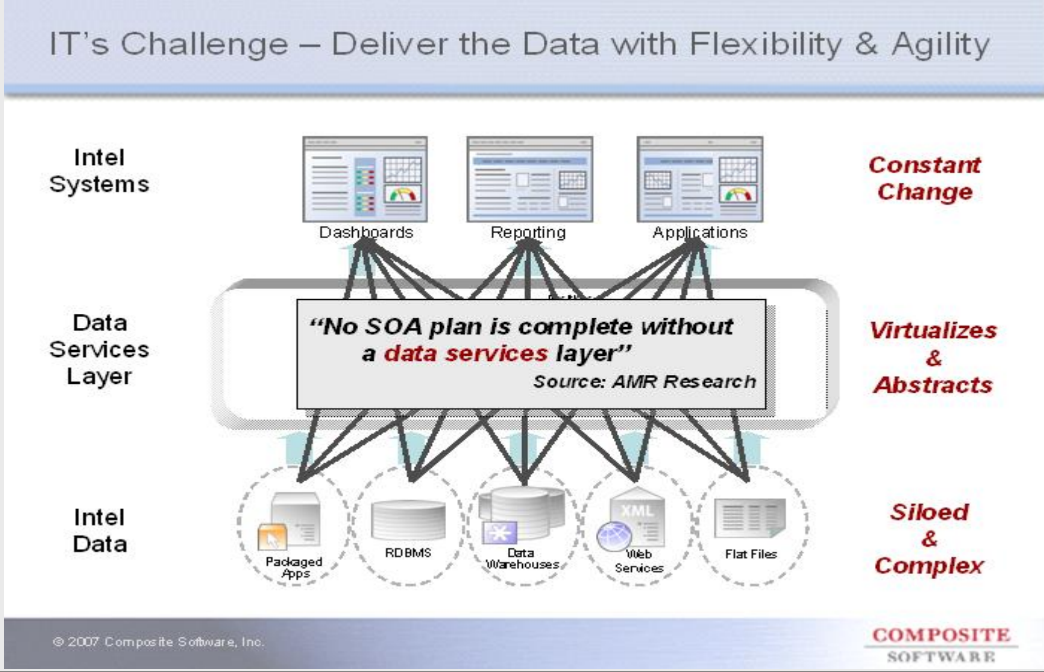
Jim Green,

Designing Reusable Software,

- Types of services:

(1) put data in, (2) get data out

- SOA & error handling => careful planning



Challenge/Approach

Hub Vandervoort, CTO, Progress/Sonic

- ***His Key concept was Enterprise Service Bus (ESB)***
  - **Service Requires alignment across 4 dimensions**
  - **Functional, (2) Structural (3) Behavioral (4) Performance**
  - **Interaction Model (-Request Reply, -Store & Forward, -Pub/Sub, –Bulk transfers)**

Steve Kahn, **Bearing Point**

- Discussed two SOA projects (Insurance Company & Commercial packaging firm)
- Focus on the business…, technology is never enough.

Some Final Thoughts

- SOA Maturity
  - Incremental approaches work best
  - Expect to get smarter along the way
- Business Process Management and SOA
  - BPM is the ultimate enabler of return on SOA investment
  - BPM is to SOA what a conductor is to an orchestra
  - Business processes are built from high-level composite services
  - Invoke business processes as services
- Knock down remaining impediments
- Maintain Leadership Support

SOA Case Studies © 2007 BearingPoint, Inc. INTEGRATION SOLUTIONS 36

Challenge/Approach

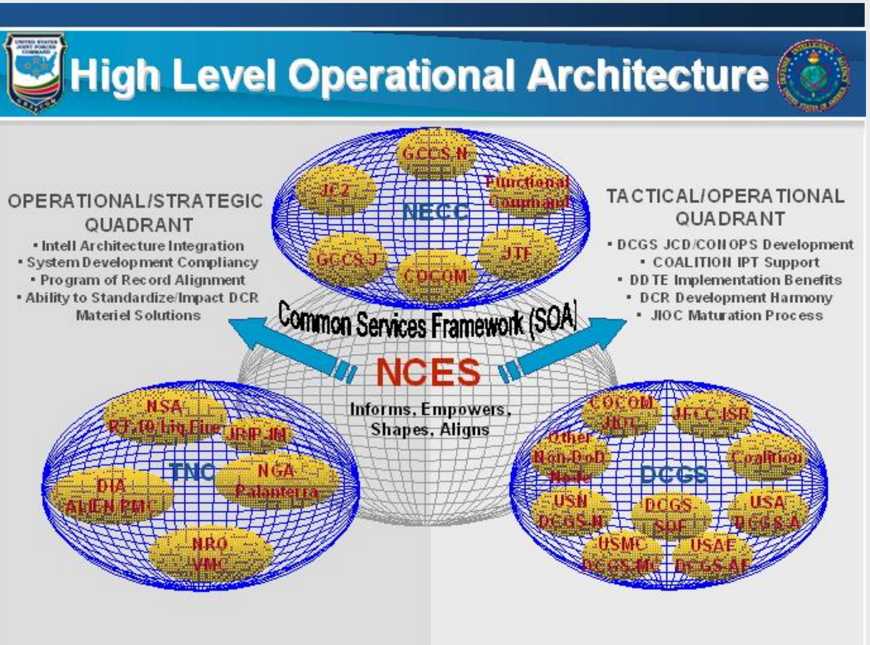
Booz | Allen | Hamilton
90 years delivering results that endure

Melissa Soley, BAH, Trans-National COP

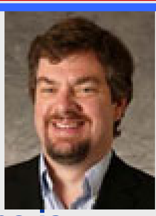
- **BAH Mission Engineering (ME) method is a bottom-up IER data capture approach**

  Very intensive data capture approach

- **Point of interest: 80% of an Intel Analyst's time is spent simply retrieving data not analyzing.**



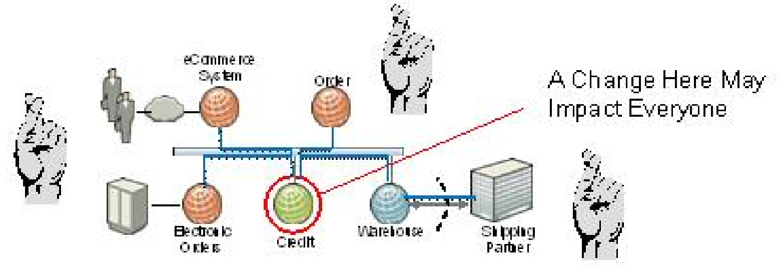
AMBERPOINT



Sean Fitts, Amber Point

- ***Keys to SOA Runtime Gov'n***
  - **Visibility => what is going on & who is using it?**
  - **Control => Actions to prevent or correct issues**
  - **Integrity => Ensuring changes don't impact the whole infrastructure**

The SOA Validation Problem
Business System Integrity Always at Risk



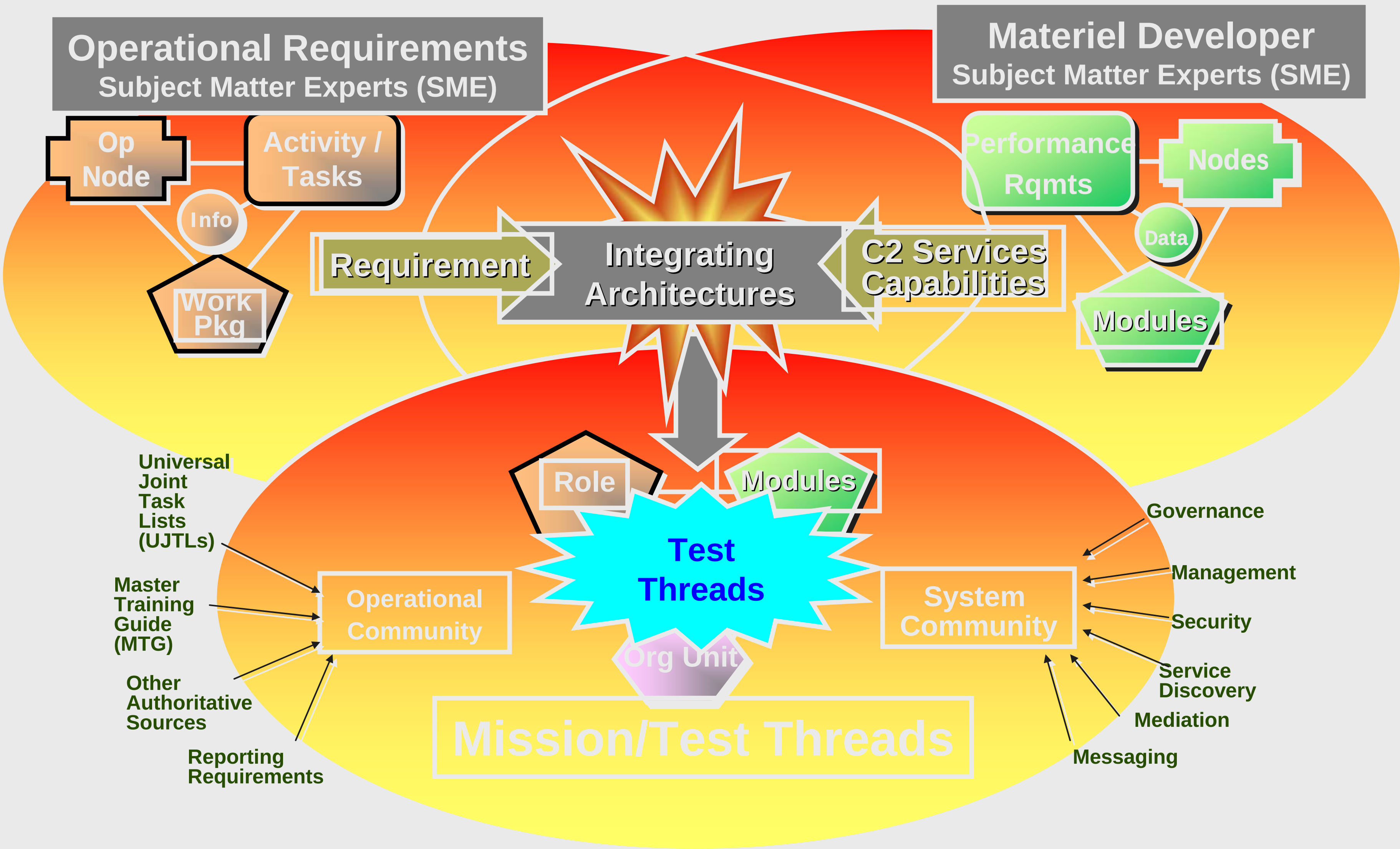
- Service reuse creates dependencies
- Impact of any changes ripple throughout the system
  - Real impact of planned changes is hard to predict
  - Impact of unplanned or unannounced changes can be devastating
- Yet, it quickly becomes impossible to setup and replicate all dependent systems for testing elsewhere

Need way to continuously check for integrity – both in staging and in production

AMBERPOINT ©2007 AmberPoint, Inc. 14

SCRA

What is our Testing Approach?

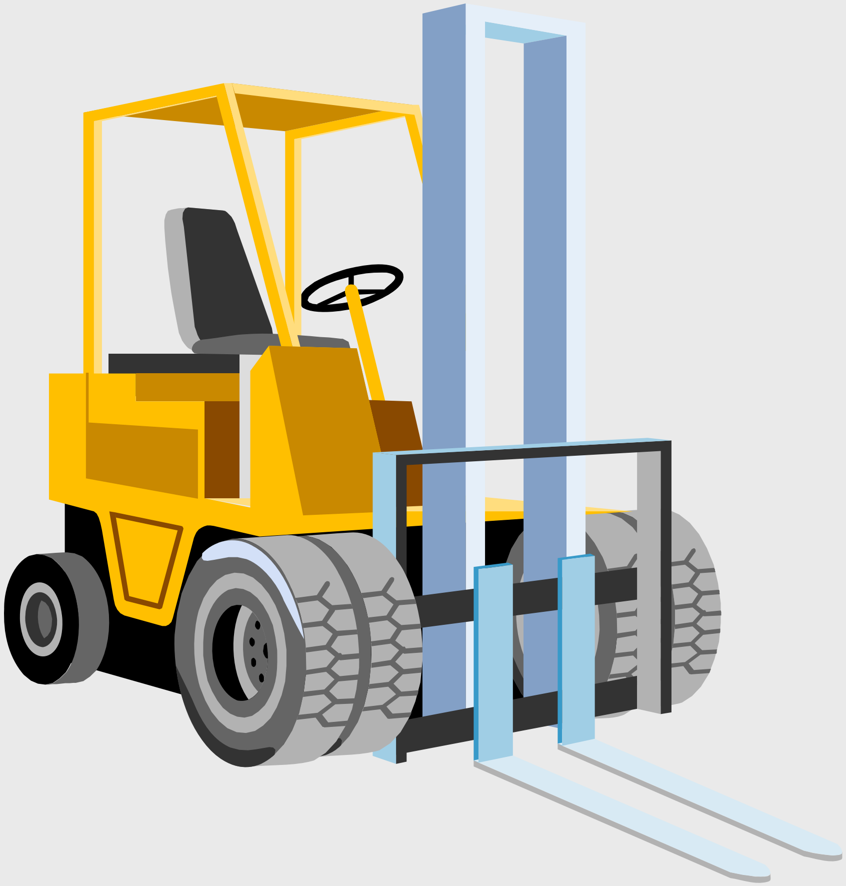


Testing CONOPS in DoD's Net-Centric Environment

So what did he say?

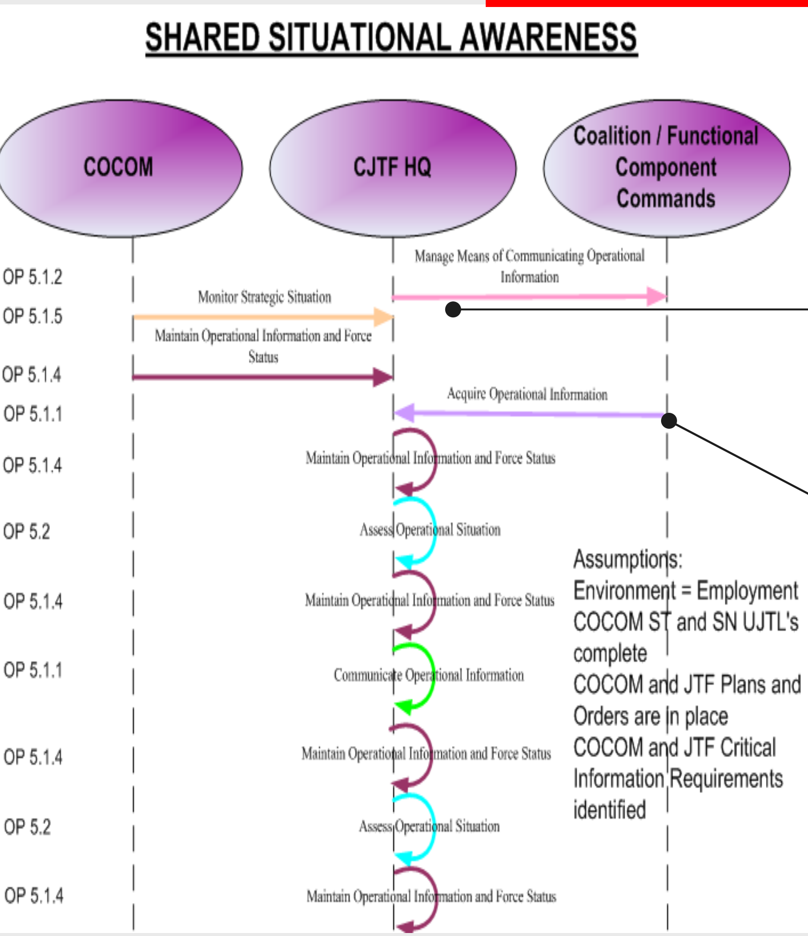
- DoD's C2 environment has @ 7 million customers
- Our business is the management of violence
- JFCOM is the Joint Warfighter Advocate
- DoD is moving to Net Centric C2
- DoD will continue to adapt to change
- Poland's military transformation & movement toward Net Centricity
- NECC programmatic processes
- Industries views
- NECC testing concept
- DoD is in the early stages of SOA adoption

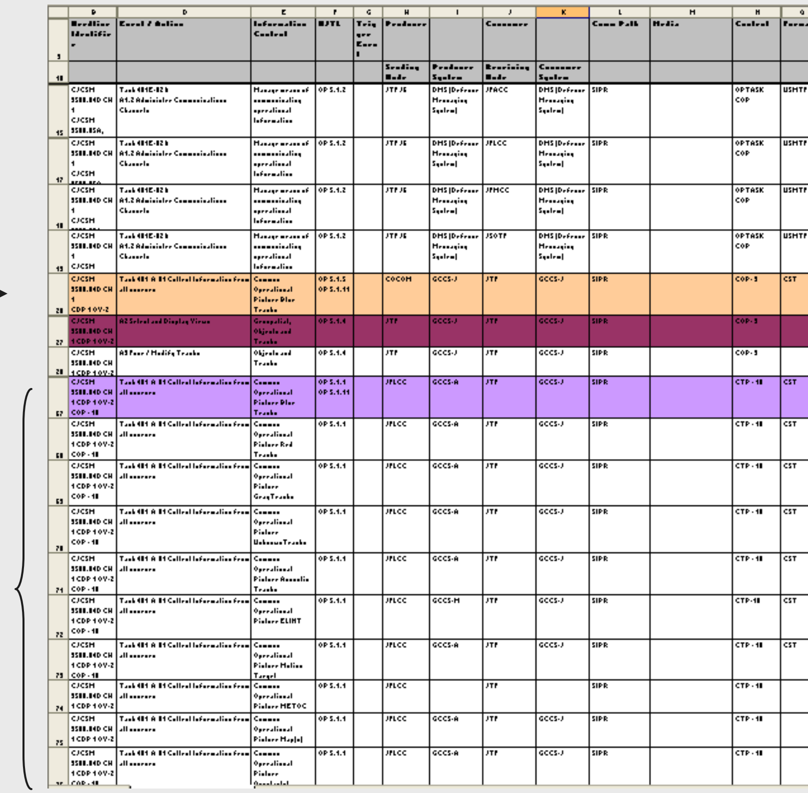
BACKUP SLIDES



What is our Approach?

Use an <u>Operational Mission Thread</u> Concept





Operational Event Trace Description (OV-6c)

Event Table

Integrated Risk and Knowledge Management for Exploration

David M. Lengyel
Risk and Knowledge Management Officer
Exploration Systems Mission Directorate
NASA Headquarters

October 24, 2007

Introduction

Objective: Introduce and discuss <u>real work process improvements</u> that utilize organizational management innovations and leverage existing ESMD information technology resources

Customer: The ESMD civil servants and contractor work force

Goal: No nonsense, straight-up, “Real Deal” approaches to make your job more fun and make you more effective

- Work more effectively and efficiently
- Make better – more risk informed decisions
- Manage risks in a proactive fashion

Not another burdensome management / administrative demand on your time …….. This stuff will save you time !

Why Integrate Risk and Knowledge Management?

Designing a complex architecture of hardware, software, ground and space-based assets to return to the Moon and then go on to Mars will require:

1) an effective strategy to learn from past lessons, and
2) a set of inter-related practices to generate and share knowledge for reuse as we progress forward. ESMD risk and knowledge management communities have embarked on an effort to integrate risk and knowledge management (KM) over the lifecycle of the Constellation and Advanced Capabilities Programs using a set of inter-related strategies, which include:

Practice 1: Establish *Pause and Learn* Processes

Practice 2: Generate and Infuse Knowledge-Based Risks (KBRs)

Practice 3: Establish Communities of Practice (CoP)

Practice 4: Provide Knowledge Sharing Forums

Practice 5: Promote Experienced-Based Training

dlengyel@hq.nasa.gov

ESMD and Stealth KM

“Knowledge-enabling processes (i.e. process improvement) will lay a solid KM foundation for future organizational evolution and help align KM with business-based goals and objectives

Improving processes also provides an opportunity to deploy supporting KM tools and techniques such as collaboration or CRM software and processes – this can give important momentum to knowledge workers, and can help them to work in a more holistic and community-based way

Bottom-line: **Process evolution equals culture evolution”**

Niall Sinclair
Author of Stealth KM

Practice 1: Pause and Learn

"The Need to Pause, Reflect, and Learn"

PaL is modeled after the Army After Action Review (AAR) system by Dr. Ed Rogers KM Architect at the GSFC.

The idea is to create a learning event at the end of selected critical events in the life of a project. End of project reflections are good but are too infrequent for the organization to learn in a timely manner.

PaL meetings are intended to be integrated into the project life cycle at key points as a natural part of the process. PaL meetings are structured and facilitated by specialists who are not project members

Attributes of a PaL

Informal, facilitated roundtable discussion (1/2 hour to full day)
- Includes moderator and rapporteur
- Focuses on tasks and goals that were to be accomplished

Not for attribution
- Does not judge success or failure (not a critique)
- Encourage employees to surface lessons

Focused on particular area of project life (phase and function)
- Management PaL, Technical PaL, Conceptual PaL, et. al.
- Team participation may vary, depending on PaL focus and objective

Maximizes participation
- Primary benefactors are the ***participants themselves***
- More project activity can be recalled and more lessons shared

Must be conducted *inside a project's schedule*, not outside or later
- Recall of key details more likely and insights can be immediately applied
- Affirms learning as integral part of project life cycle

PaL as a Process

Step 1
- Identify when PaLs will occur
- Determine who will attend PaLs
- Select Moderators, Rapporteurs
- Select potential PAL sites
- Review the PAL plan

Step 2
- Review what was supposed to happen
- Establish what happened (esp. dissenting points of view)
- Determine what was right or wrong with what happened
- Determine how the task should be done differently next time

Step 3
- Review objectives, tasks, and common procedures
- Identify key events
- Rapporteurs collect *ALL* observations
- Organize observations (identify key discussion or teaching points)

[1] **Adapted from United States Army Manual: A Leader's Guide To After Action Reviews**

Definition

Knowledge-Based Risk *n.* **1.** A risk based on lessons learned from previous experience. **2.** A closed risk with documented lessons learned appended. **3.** A means of transferring knowledge in a risk context.

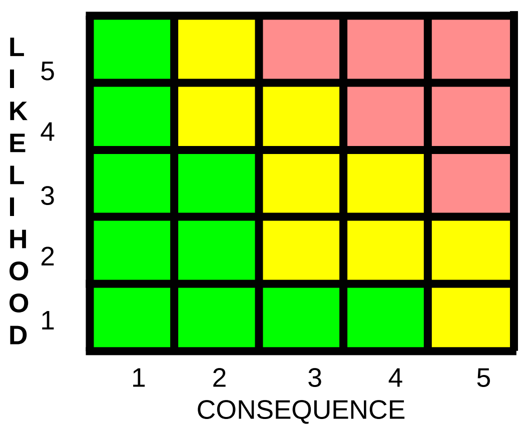
Lessons Learned on Lessons Learned

- **Start Early**
- **Need to Capture, Learn From and Repeat Successes--Need to Learn from and Prevent Failures, Mishaps, Near Misses**
- **There was a limited number of useful lessons learned in the NASA Lessons Learned Information System database. The good ones are masked by the hundreds of poor ones, so that extensive effort is required to sort them out.**
- **Lesson Learned – Well-understood mechanisms for "transfer of knowledge" during Program development are crucial to a successful long-term Program.**
- **Flow <u>all</u> applicable Lessons Learned into Requirements, Processes, and Plans. Institutionalize the Use of Lessons Learned.**
- **Provide Sufficient Resources, Planning, and Management Support to Analyze and Incorporate Lessons Learned. NASA and Contractor Must Work Together**
- **The best lessons learned for running a major program should be captured in a *<u>living handbook of best practices</u>*. New lessons learned should be screened for applicability, and included in the handbook.**

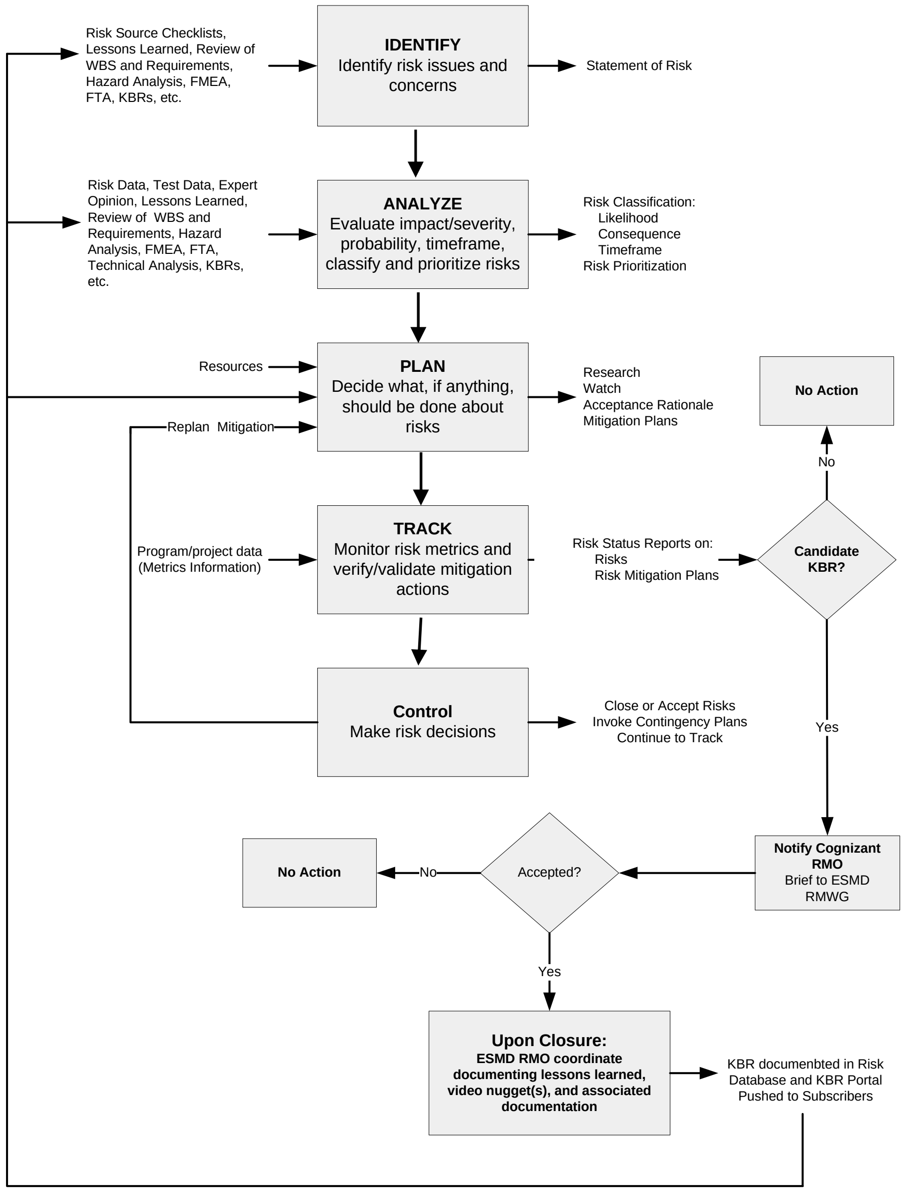
ESMD Is Taking a New Approach to Lessons Learned…..

Knowledge-Based Risks Strategy

The ESMD KBR strategy is intended to convey risk-related lessons learned and best practices to ESMD personnel. This strategy integrates the existing Continuous Risk Management (CRM) paradigm used at NASA with knowledge management--with the primary focus on integrating transfer of knowledge through existing work processes and not adding an additional burden to the workforce to incorporate new KM tools and concepts.



KBR Process Flow Chart



- **KBRs are documented as a requirement in ESMD Risk Management Plan – this flows down to Levels 2 and 3 (Program and Project) Risk Management Plans**
- **Leverages Standard Continuous Risk Management (CRM) paradigm**
- **Adds filtering process for identifying significant risks as KBR candidates**
- **Captures “What worked – OR – Didn’t work in terms of mitigation strategies**
- **Provides Infusion Process for KBRs Back Into Risk Management and other processes Which current NASA Lessons Learned System lacks**

KBR Criteria

Risks that are "Candidate KBRs" should meet several of the following criteria (listed in order of importance):

(1) Were mitigated (not accepted or watched)

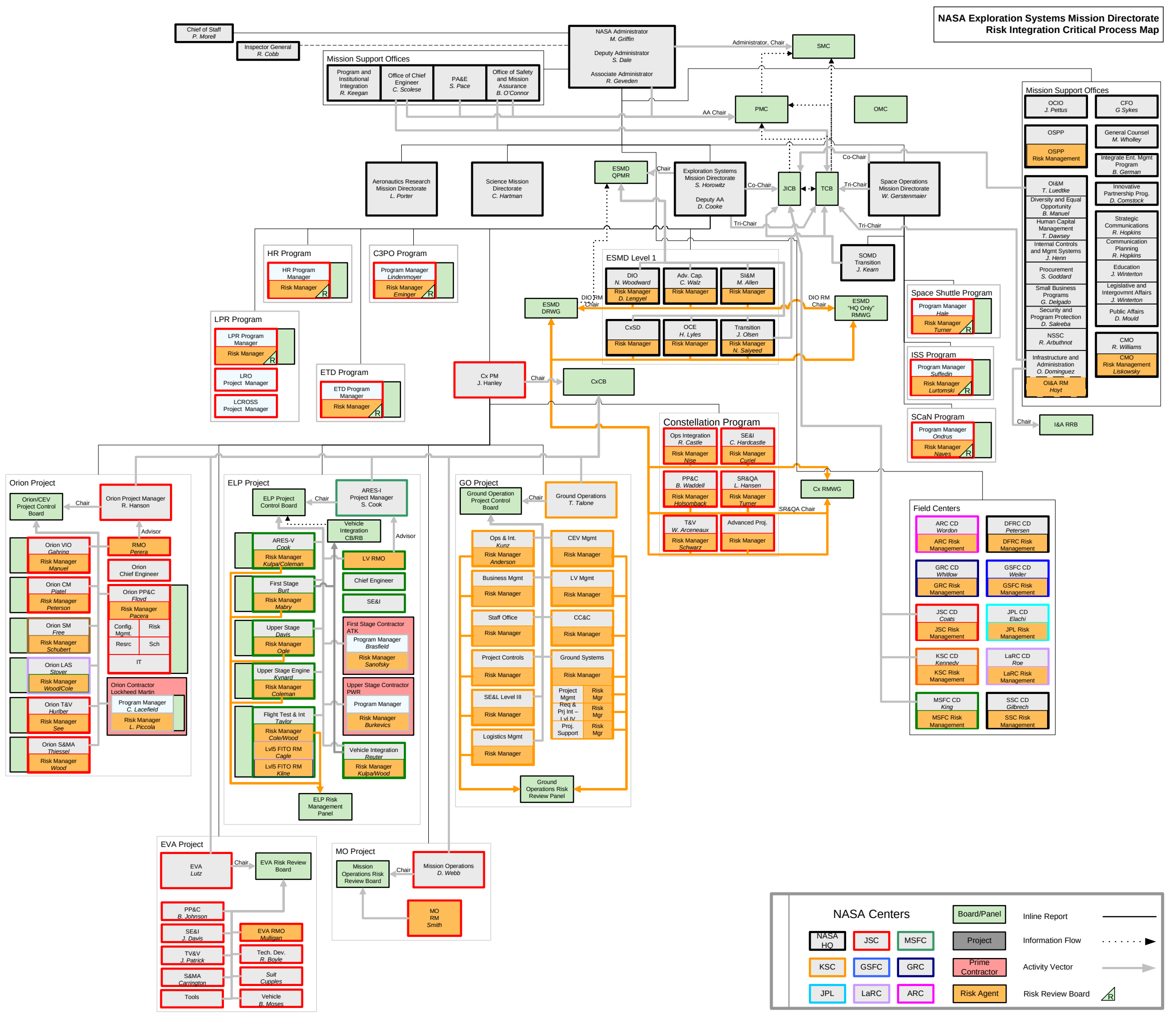
(2) Will likely appear again in other programs / projects

(3) Included a particularly effective mitigation approach / implementation, or an error in mitigation planning or implementation could have been avoided

(4) Was on the performing organization's Top Risk List at some point during the life cycle

(5) Was owned (and/or worked on) by a particularly knowledgeable person who could serve as a "expert" on the risk topic

Application of Risk Management Assurance Mapping



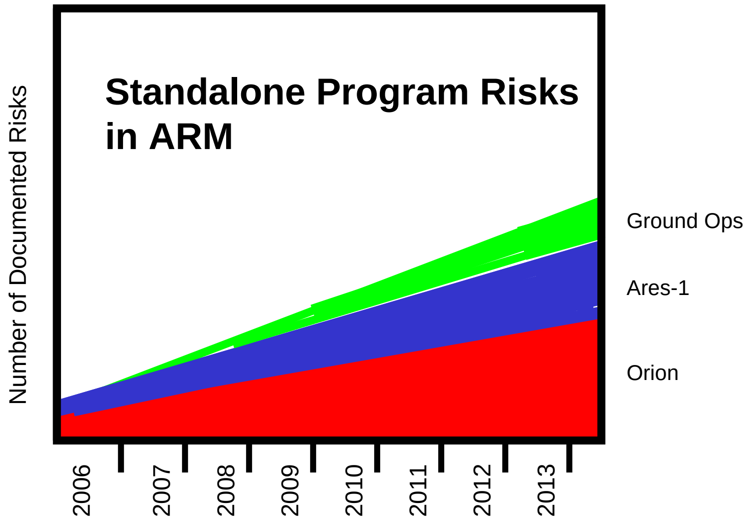
Multiple KBR Capture Points – Multiple Delivery Points

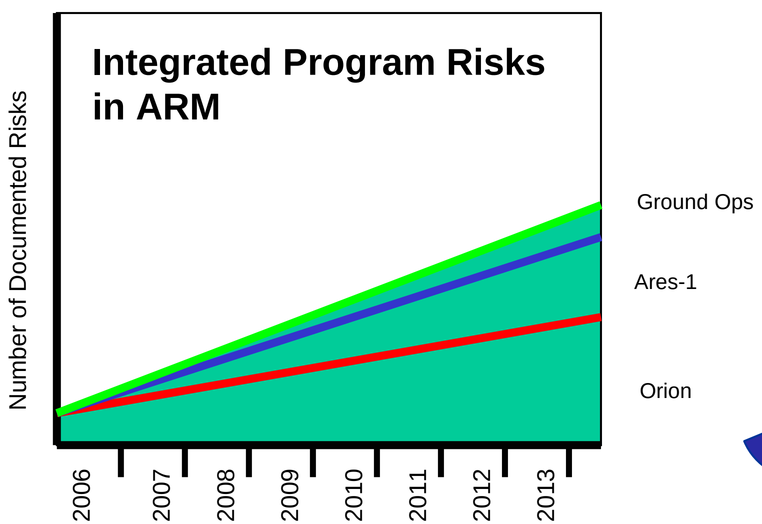
Internal and External to ESMD

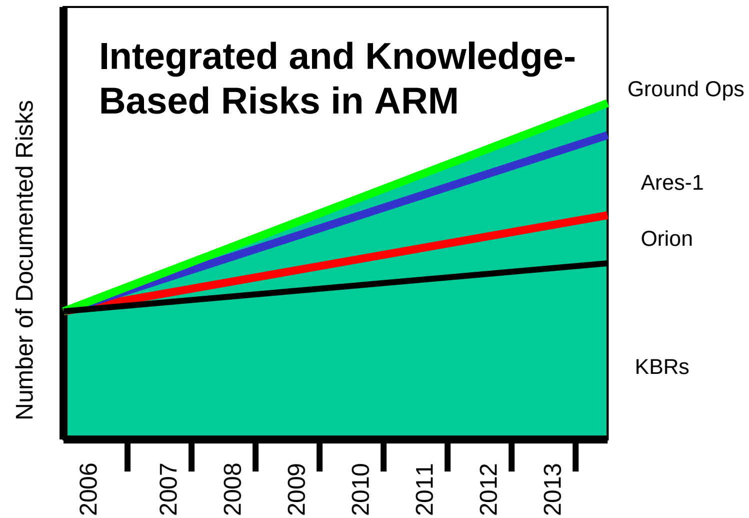
Knowledge-Based Risks (Continued)

More access to risk information is required to close "knowledge gaps"

KBRs will become a living reference over time as risks are identified, mitigated and closed







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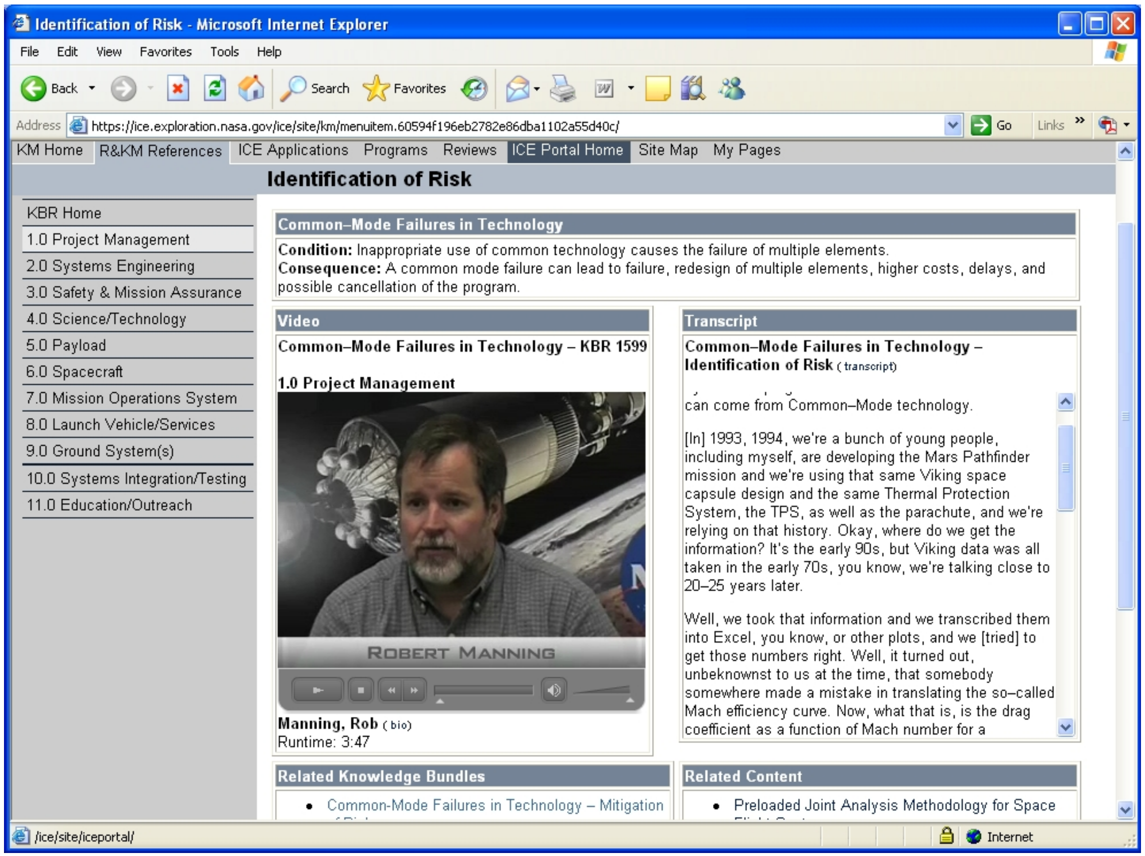
Knowledge-Based Risks (Continued)

NASA Standard WBS

ARM allows automated delivery of new KBRs

Knowledge-Based Risks (Continued)

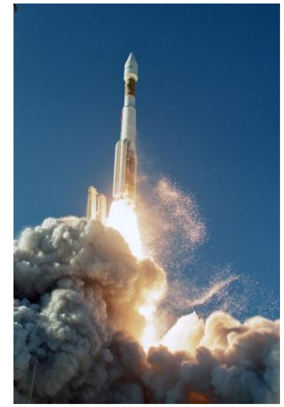


- **Embedded 3-8 min Video Nugget with Transcript**
- **Related Knowledge Bundles**
- **Related Content – reports, documents, etc.**
- **Threaded discussion (blog) feature to be added to comment on each KBR**
- **Hosted on ESMD R&KM portal**

First Closed Risk KBR – Lunar Recon Orbiter

LRO Spacecraft

Delta II Booster



Atlas V Booster

LCROSS Spacecraft

- **The design of the LRO propulsion tanks was influenced by a number of factors including launch vehicle characteristics. The Delta II Expendable Launch Vehicle's (ELV) spin stabilized upper stage made the Nutation Time Constant (NTC) a key parameter in assessing the stability of the spacecraft. The uncertainty in predicting the effects of liquid propellant motions and the relatively large propellant load and mass fraction for the LRO tank resulted in the identification of a potential risk. Close coordination and communication with all levels of management early in the design trade study process allowed for the effective mitigation of the risk and provided additional lunar exploration opportunity.**

Practice 3: Communities of Practice

Knowledge resides with people and is often lost via actions like:

- **Downsizing**
- **Retirements**
- **Shuttle Transition**
- **People Movement**

Participation in a CoP should be considered part of any professional's career growth

Communities of Practice (Continued)

"Communities of Practice (CoP) are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis"

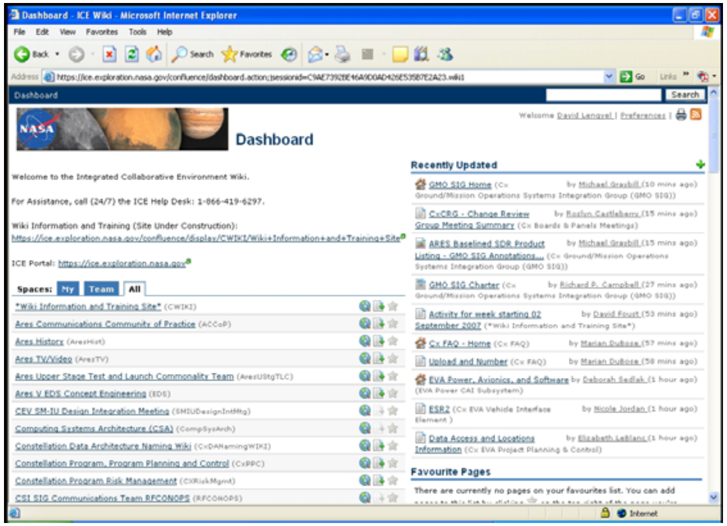
"CoPs share information, insight and advice. They help each other solve problems."

"They may create tools, standards, generic designs, manuals, and other documents—"

"Cultivating CoP in strategic areas is a practical way to manage knowledge as an asset, just as systematically as companies manage other critical assets."

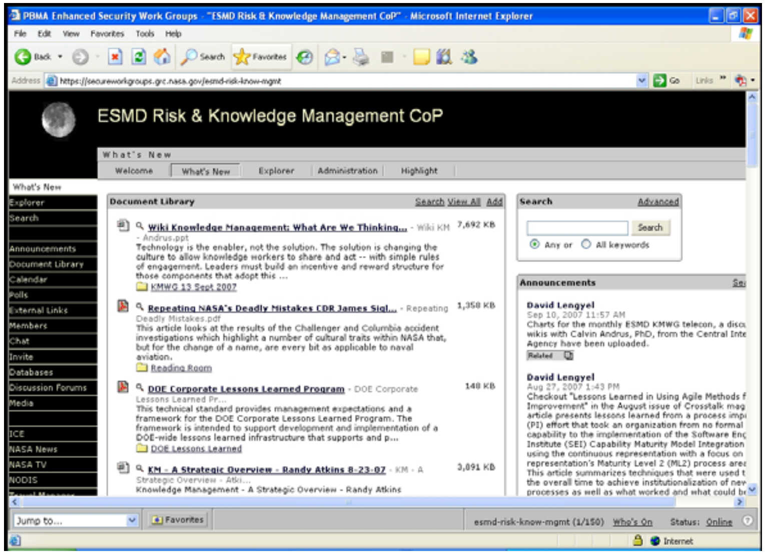
Communities of Practice. Wenger, et al

IT Enabling ESMD CoPs in a Secure Environment



The **Confluence Wiki** provides secure collaborative functionality within the ESMD Integrated Collaborative Environment (ICE). ESMD Wiki spaces now number over 130

The **PBMA toolkit** provides NASA CoPs with a secure environment to share documents, conduct threaded discussions, polls, manage calendars, locate expertise, collaborate and learn. Over 30 ESMD CoPs are serviced by PBMA.



Practice 4: Knowledge Sharing Forums

ESMD Alumni Sharing Events:
- **These events bring in alumni from Apollo, Space Shuttle, and other programs to discuss their experiences and lessons learned**
- **This is an extensive, under-utilized knowledge base**
- **ESMD has invited selected alumni to brown bag lunches and other lessons learned forums**

Knowledge Sharing Workshops and Seminars:
- **At Knowledge Sharing Workshops, senior project leaders share their insights, what they learned and what they might have done differently based on a recent project experience.**
- **These workshops are attended by emerging project leaders who want to understand the wisdom of successful project managers**

APPEL Master's Forums:
- **Conducted twice annually**
- **ESMD has and will continue to participate in these events**

Practice 5: Experienced-Based Training

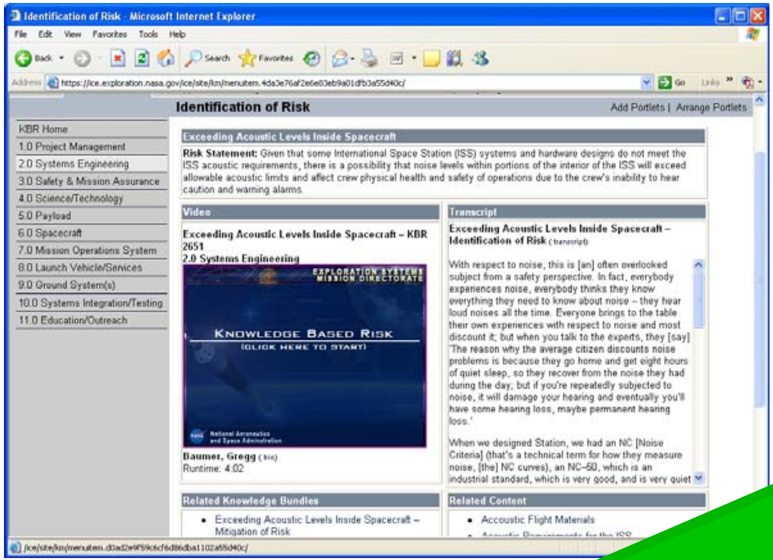
Project Management and Engineering Training

- **Already conducted by APPEL and NESC Academy**
- **ESMD will focus its efforts in training on leveraging the existing infrastructure of training courses throughout NASA**
- **ESMD will help shape existing courses by providing ESMD-related experiences, gleaned from case studies, KBRs, and other sources of lessons**

Case Studies

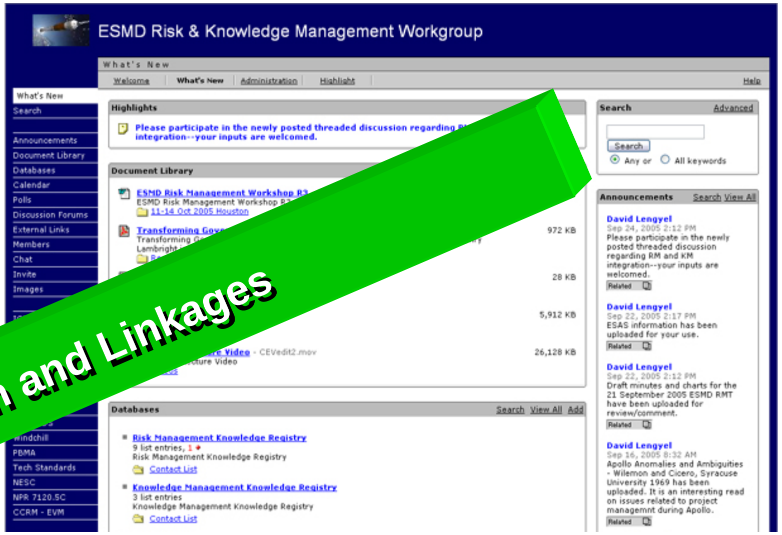
- **ESMD will facilitate the development of case studies that will help transfer the context of program/project decisions to the workforce and emerging leaders**
- **Senior ESMD managers would help shape the content based on their experiences and leadership**
- **Case studies will make existing training programs more relevant and useful to upcoming ESMD leaders who participate**

KM Practices and Tool Integration



Portals

Wikis/CoPs



Rich Integration and Linkages

Engineering / Management Training

Knowledge-Sharing Forums

ESMD Risk & KM Teaming

ESMD is teamed with:

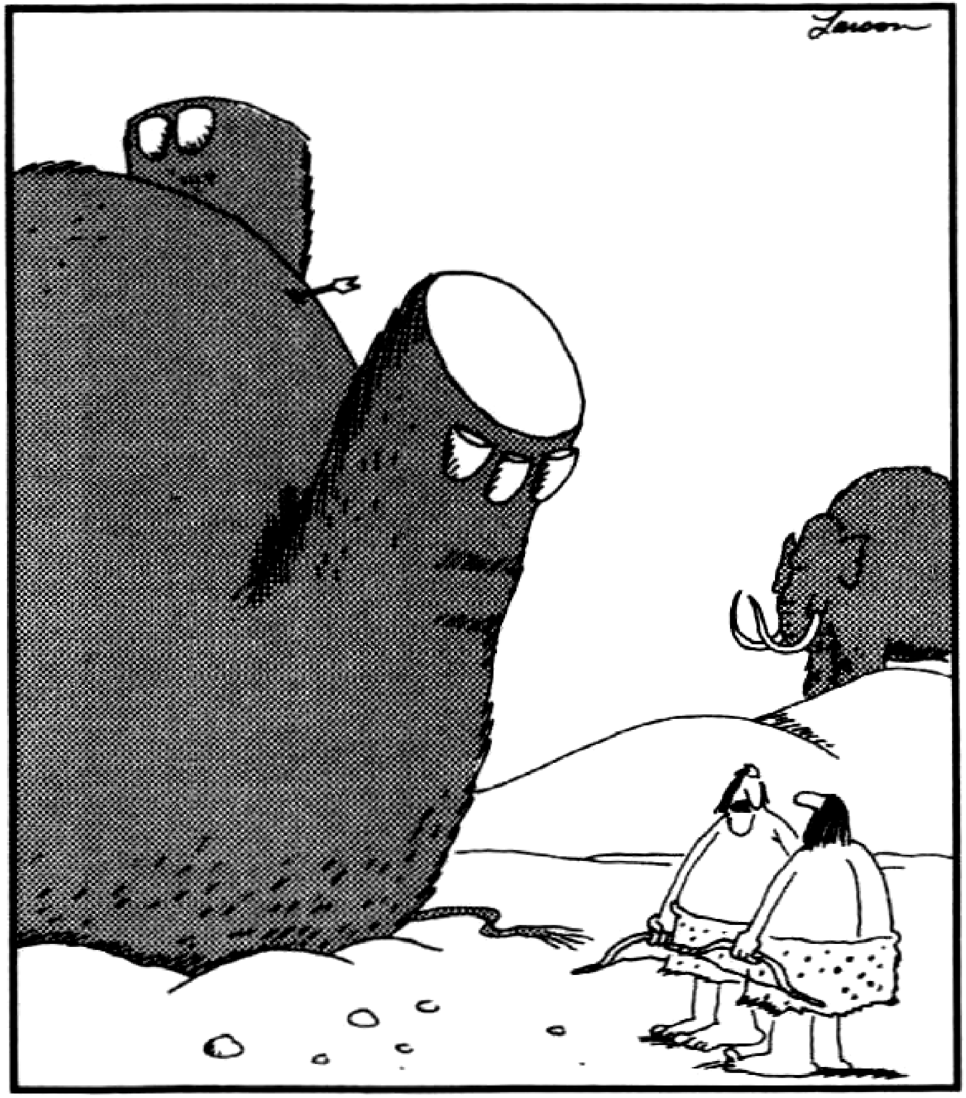
- Space Operations Mission Directorate
- Office of Safety & Mission Assurance
- NASA HQ Institutions & Administration
- Academy of Program / Project & Engineering Leadership
- NASA Engineering & Safety Center (NESC) Academy
- JSC Chief Knowledge Officer
- GSFC Chief Knowledge Officer
- MSFC / Ares Chief Knowledge Officer
- Constellation Program
- ISS Program
- SSP Program
- Pratt-Whitney-Rocketdyne Chief Knowledge Officer
- Lockheed-Martin
- ATK-Thiokal
- United Space Alliance, Office of the Chief Engineer
- The Aerospace Corporation
- NASA Alumni Association
- Defense Acquisition University – Best Practices Clearinghouse

Summary

“ESMD faces exciting opportunities and formidable challenges. To reduce risk and apply knowledge more effectively, ESMD should integrate its KM, RM and OL initiatives into a comprehensive plan that will accomplish more with less bureaucracy. The goal is not compliance with detailed processes and procedures but compliance with intent: the intent to learn, to share and probe every possible angle so ESMD’s missions have the highest possible chance of success. ESMD must take risks with ‘eyes wide open’ and ‘minds fully engaged’ at every decision, every trade and with every residual risk.”

From: Strategy for Exploration Systems Mission Directorate
Integrated Risk Management, Knowledge Management
and Organizational Learning Whitepaper
Dave Lengyel & Dr. Ed Rogers

Questions?



“We should write that spot down.”

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CMMI—Update and Next Steps

NDIA Systems Engineering Conference
24 October 2007

Ms. Kristen Baldwin

OUSD(AT&L) Deputy Director,
Software Engineering and Systems Assurance

Outline

- CMMI-DEV Guidebook for Acquirers
- CMMI for Acquisition (CMM-ACQ)
- CMMI Next Steps Beyond v1.2
- CMMI Constellations, Focus Topics and Moving Forward

CMMI: Implementation Issues

- Developers execute at lower maturity levels than their organizations have achieved and advertised
- Assurance that new projects will incorporate CMMI processes
- Appraiser quality – training, consistency
- Lack of agreement on what constitutes Levels 4 and 5
  - Requirements for demonstrated behavior
  - Definition of Levels 4 and 5 themselves
- Appraisal disclosure statement content
  - Coverage of the organization appraised
  - Performance on individual process areas
- Training and education for acquirers
- CMMI misuse in source selection

Proper use of CMMI requires knowledge of these issues

Understanding and Leveraging a Supplier's CMMI Efforts: A Guidebook for Acquirers

CMMI Acquirer's Guidebook

- Designed to help an acquirer benefit from a supplier's use of CMMI-DEV while avoiding the pitfalls associated with unrealistic expectations related to CMMI level ratings
- Readable (small) 40 pages for the Program Manager
  - Available at http://www.sei.cmu.edu/publications/documents/07.reports/07tr004.html
- Part of the CMMI Product Suite
  - Change requests and comments can be submitted to cmmi-comments@sei.cmu.edu.
  - Will be updated with learning and experience
- Will be made into a Continuous Learning Module for acquirer training with the Defense Acquisition University

Key Tips in the Guidebook

- Do not ask for CMMI maturity levels in RFPs
  - Ask for capability in processes that are key to the success of your program
- Read the Appraisal Disclosure Statement (ADS)
  - Determine what part of the organization was actually appraised and how it relates to your program
  - For high maturity (levels 4 and 5), determine what processes were actually improved
  - Ask for clarification, appraisal findings if needed
- Recognize that levels are a result of appraisals that cost money
  - Can achieve results using other assessment techniques
  - Can do post-award checks to ensure your project is implementing its promised processes

High capability and maturity level ratings do not of themselves guarantee program success

Guidebook Bottom Line

- DoD does not place significant emphasis on capability level or maturity level ratings
  - Promotes CMMI as a tool for internal process improvement
- Lack of emphasis on ratings is prudent
  - Findings that not all suppliers are exhibiting behavior consistent with their attained CMMI maturity level rating
- Essential that DoD and industry use CMMI capability in the right manner, with appropriate measure, in order to realize benefits
  - CMMI-DEV provides a set of best practices to be employed by the supplier

7

CMMI for Acquisition
1 Nov 07 release

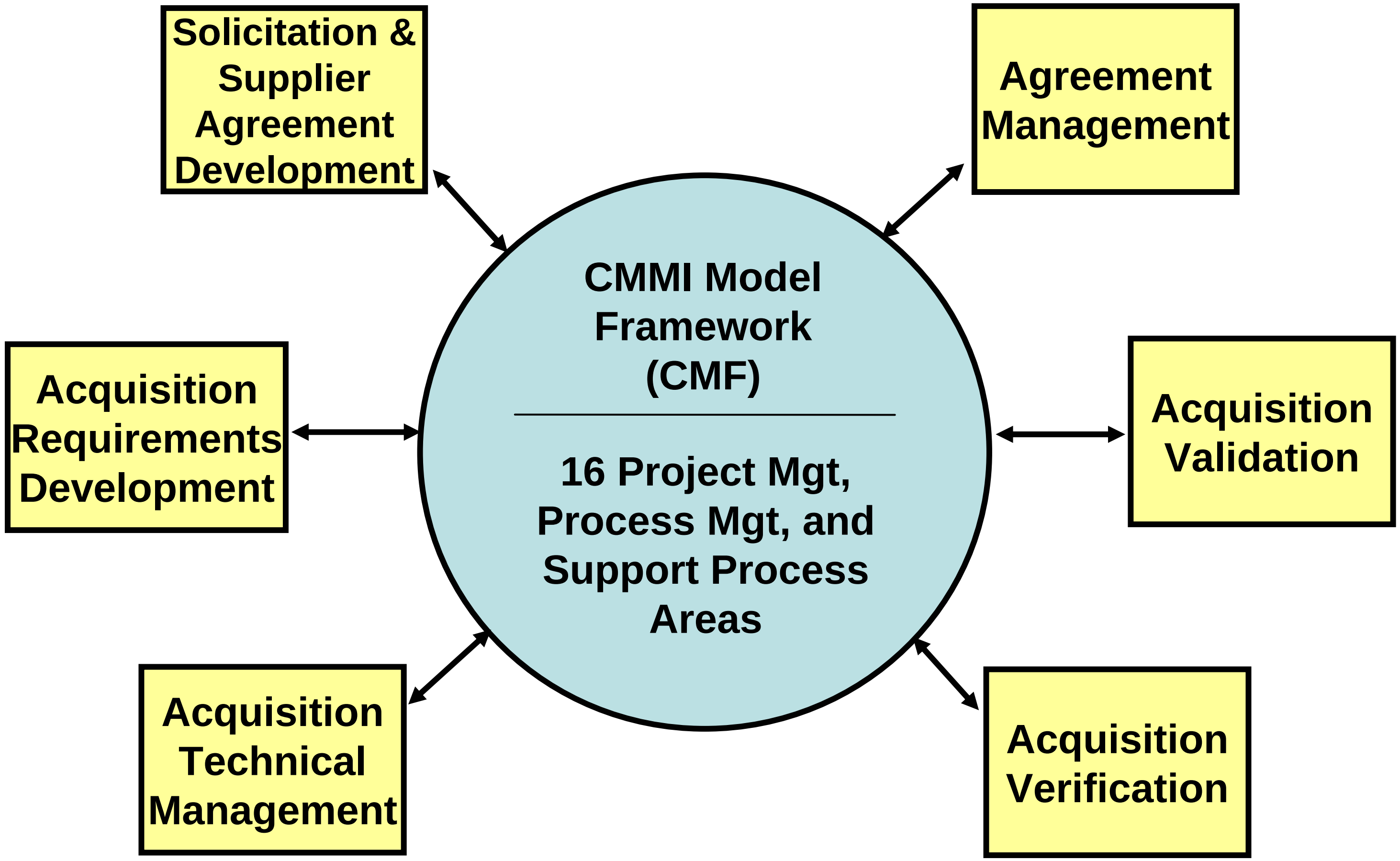
CMMI-ACQ Development Strategy

- General Motors and the SEI developed the initial draft model
  - Source models included CMMI Acquisition Module (CMMI-AM) and Software Acquisition Capability Maturity Model (SA-CMM)
  - Incorporated lessons from several acquisition organizations to adapt the CMMI-DEV to their organization
  - Pilots from several acquisition organizations (DHS, GAO, Army, GM, others)
- Model Team dispositioned over 700 change requests from stakeholder review and workshop to develop and peer review recommended changes to initial draft
- Advisory Board of government and industry stakeholders established as change control board
- v0.9 piloted at one defense agency and one commercial company
- Steering Group endorsed final product as part of the v1.2 product suite
- Will be published on 1 November, available at http://www.sei.cmu.edu/cmmi/models/index.html

CMMI-ACQ Development Challenges

- Model had to explicitly apply to the acquisition of both products and services
  - From IT outsourcing to DoD acquisition of a weapon system
  - Applicable internationally-recognized references and glossary terms added, e.g., service level measurement
- Model had to apply to spectrum of acquisition organizations from commercial industry to government agencies, both large and small

CMMI-ACQ v1.2
Acquisition Category Process Areas



ACQ PAs seamlessly interact with all CMF PAs through ACQ-specific material added to CMF PAs

Acquisition Specific-Practice Enhancements to CMF PAs

- Measurement and Analysis
  - Includes earned value management material
  - Consistency across the model in measurement terms
- Project Planning
  - Includes establishment and maintenance of a project's acquisition strategy
- Project Planning and Project Monitoring and Control
  - Includes important specific practices on transition to operations and support
- Integrated Project Management and Organizational Process Development
  - Includes material on integrated teaming
  - Crucial to stakeholder involvement for acquisitions in a system of system environment

Highlights of Acquisition PAs

- Solicitation and Supplier Agreement Development (SSAD) and Agreement Management (AM)
  - Similar to Supplier Agreement Management in CMMI-DEV but greatly expanded into 2 PAs
  - Covers both legal contracts and other forms of supplier agreements such as interagency MOAs

- Acquisition Requirements Development
  - Similar to Requirements Development in CMMI-DEV, but develops customer and contractual requirements
  - At maturity level 2 due to its importance in acquisition

Highlights of Acquisition PAs

- Acquisition Technical Management
  - Emphasizes technical reviews and technical performance measurement for oversight of the supplier
  - Interface Management included to complement the other kinds of technical management process areas (e.g., Risk Management, Requirements Management)

- Acquisition Verification and Acquisition Validation
  - Similar to CMMI-DEV Verification and Validation PAs but enhanced for the acquirer

CMMI Next Steps:
Beyond v1.2

Questions for v2.0 of the Models and Appraisal Method

- Do we need something different or additional to define High Maturity (i.e. CMMI Level 4 & 5)?
- How can we apply Lean techniques to CMMI models? Appraisal methods?
- Can we eliminate the Staged representation?
- Is the CMMI v1.2 Constellation Strategy the right approach?
- Can we identify “next-generation” process improvement methodology?
- Can CMMI be harmonized with other continuous process improvement efforts?
- Can repeatability, consistency and overall model and appraisal methodology be improved?
- Are there “breakthrough” concepts that we can apply to overall process improvement?

Excerpts from Next Gen PI Workshops

- Leaning the model
  - Can we lean for small projects? Can the model have some scalability according to various factors (e.g., project size, PoP, organization size)?
  - Consider options for packaging (remove redundancy or repackage)
  - Consider fundamental, intermediate and advanced volumes
  - Consider architectural views for appropriate for the different using communities
- Levels 4-5
  - Combine levels 4 and 5 into one level because of their close tie
  - 4 and 5 are not adequately elaborated for implementation - may need more detail to drive proper behavior
  - Consider maturity levels within PAs (e.g., project management PAs for each level)
- Constellations – the right approach?
  - Alternative approach: Start with a CMMI Model Framework (CMF) and add where you need to, expand scope (+ concept)
  - Instead of creating constellations, encourage projects to do what makes sense with respect to what they are doing using the parent model

Excerpts, continued

- Next Gen PI ideas
  - Consider better interfacing approaches with other methodologies (e.g., six sigma for high maturity)
  - Consider how CMMI could interface with other process improvement methodologies (e.g. Lean, PMBOK, theory of constraints, next generation IDEAL)
  - Consider an emphasis on process performance effectiveness and efficiency, (e.g., effectiveness 6 sigma, efficiency LEAN)
- Leaning Appraisals
  - Consider notion of visits or interim steps (like ISO surveillance audits)
  - Focus on correlation between results and performance (process reviews)
  - Make some assumptions that some processes are in place (e.g., assume project planning has happened, but don’t look at PP specifically unless you see something out of place in PMC; similarly, could start with IPM for a level 3, or QPM for a level 4)

Next Steps:
CMMI Constellations and
Focus Topics

Dealing with Two Constellations in the Product Suite

- The following questions need to be considered
  - How does an organization that does both development and acquisition use both models effectively?
  - How does an organization that uses both models have efficient appraisals?
  - How to keep the CMF consistent
    - CMMI-ACQ identified changes needed in the CMF shared material
    - There is now a mismatch with CMMI-DEV v1.2
  - How to ensure appraiser and instructor qualifications for the new model?
  - How do we accomplish training?

CMMI for the Service Sector: Some Questions to be Addressed

- What is the requirement/problem to be solved?
- What distinguishes CMMI-SVC from CMMI-DEV and ACQ? Other process models?
- What are the characteristics of Service providers?
- Is there known benefit from Service-specific process improvement? From Service-specific practices?
- Can the broad spectrum of Services be governed by a single model?
- How should Service Sector needs be incorporated into the CMMI product suite?

We are currently evaluating these questions

CMMI Focus Topics: Business Rules

What is a Focus Topic?

- Focus Topics provide additional guidance for the development of CMMI-based internal processes within an area of interest
- Examples of Focus Topics: SoS, Safety, Security, COTS

Business Rules for Focus Topics:

- They provide a “thread” through existing process areas to augment or highlight a specialty area of importance to an acquirer or developer
- They do not introduce new process areas or specific goals
- Documented as Technical Notes (TNs)
- Appraisals shall not include reference to Focus Topics as part of the appraisal ratings
  - Progress against Focus Topics can be included in appraisal findings for the purpose of identifying strengths and weaknesses.
- Shall adhere to the CMMI Architecture Document
- Steering Group and Sponsors informed of the possible Focus Topic TN and its proposed development plan before work is begun by the SEI
- SEI publishes the TN after a suitable set of reviews have been completed and comments have been dispositioned and accepted

Ensure all parts of the product suite are consistent and managed

Moving Forward

- Evaluate changes to the CMMI v1.2 product suite to ensure improvement goals are really being met
  - Integrity of appraisals
  - Quality of the product suite
  - Education of acquirers
  - Opportunities for streamlining where appropriate
- Re-look levels 4 and 5
  - Consistent definition and appraisal
  - Relationship to other models (e.g. 6 sigma)
  - Appraiser and implementer training and understanding
- Monitor Cost Impacts and Return on Investment
  - All changes to the suite have impacts on industry and government, direct and indirect
  - Need cost impact data from you!!

Questions/Comments?

Guidebook:
http://www.sei.cmu.edu/publications/documents/07.reports/07tr004.html

CMMI-ACQ Model:

http://www.sei.cmu.edu/cmmi/models/index.html

CMMI-AM Module:

http://www.sei.cmu.edu/publications/documents/05.reports/05tr011.html

Ideas for Next Gen PI:

Comment forms available on SEI website

BACKUP

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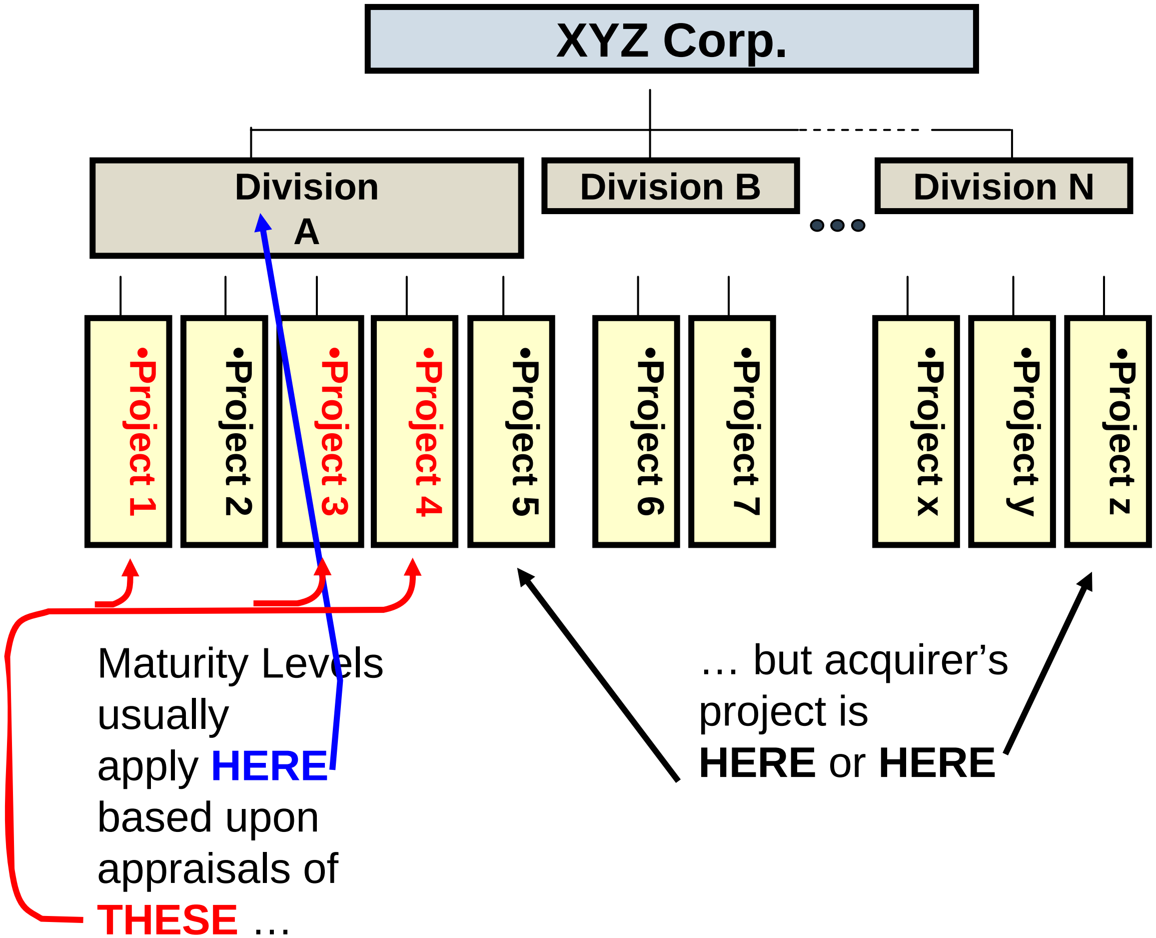
Example: Published maturity levels may be based on a single location



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CMMI-ACQ Plan for V2.0

- V1.2 concentrated on the project-, or program-level acquisition best practices
- V2.0 will add more of the enterprise/ organization level best practices for acquisition
  - Address enterprise level acquisition strategies
    - Preferred supplier strategies
  - Address the Program Executive Office level
- V2.0 will also benefit from change requests issued from lessons learned using the model globally

System Engineering in a System of Systems Environment

A Defense Update

Dr. Judith Dahmann
The MITRE Corporation

Kristen Baldwin
OUSD (A&T) SSE/SSA

NDIA SE Conference
October 2007

System of Systems:

A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities. **DoD Defense Acquisition Guide, System of Systems Engineering**

Accomplishments and Plans

- Completed SoS SE Guide v.9 in December 2006
- Executed six month pilot phase
  - Identified key SoS SE elements and principles
  - Identified SoS SE issues which require further attention
- Socializing insights (SE Forum, INCOSE, NASA, SSTC Conference, NDIA, others)
- Next Steps
  - Update SoS SE Guide with pilot findings
  - Update DoD SE Guides (SEP, DAG) for SoS considerations
  - Plan for DAU Continuous Learning Module in FY08
  - Implement FY08 activities to address identified issues

A mechanism to share emerging insights on SoS and implications for SE

Pilot Participants

Objective of the pilots was to gain a ‘boots on the ground’ perspective

Research Community

INCOSE: International Council on SE

MIT: Massachusetts Institute of Technology

MITRE: MITRE Corporation

Purdue: School of Engineering

SEI: Software Engineering Institute

Stevens: Institute of Technology

USC: University of Southern California

UCSD: University of California San Diego

Australia: Defence Materiel Organisation

SE Practitioners

ABCS: Army Battle Command System

AOC: Air Operations Center

BMDS: Ballistic Missile Defense System

CAC2S: Common Aviation Command & Control System

DCGS-AF: Distributed Common Ground Station (MITRE)

DoDIIS: DoD Intelligence Information System (MITRE)

FCS: Future Combat Systems

MILSATCOM: Military Satellite Communications

NIFC-CA: Naval Integrated Fire Control – Counter Air

SR: Space Radar

NSA: National Security Agency

NSWC: Naval Surface Warfare Center Dahlgren

PEO GCS: Ground Combat Systems

SIAP: Single Integrated Air Picture

SMC: Space and Missile Systems Center

TMIP: Theater Medical Information Systems – Joint

USGC: US Coast Guard C2 Convergence (MITRE)

SoS: Is It New?

Insights From Pilots

- Most military systems today are part of an SoS whether or not explicitly recognized
  - Most systems are created and evolve without <u>explicit</u> SE at the SoS level
- A formal SoS comes into existence when something occurs to trigger recognition of SoS
- An organization is identified as 'responsible for' the SoS 'area' along with definition of the objective of the SoS
  - Does not include changes in ownership of the systems in the SoS
- The SoS is then structured
  - Membership is defined starting with identification of systems in the SoS
  - Processes and organizations are established for the SoS, including SE

SoS in the DoD is not new;
Recognizing SoS in development, and recognizing SoS SE is new

What Does SoS Look Like in the DoD Today?

Insights From Pilots

- Typically an overlay or ensemble of individual systems brought together to satisfy user capability needs
- Not new acquisitions per se
  - Cases like FCS are extremely rare and, in practice, still must integrate with legacy systems
- SoS 'manager' does not control the requirements or funding for the individual systems
  - May be in a role of influencing rather than directing, impacts SE approach
- Focus of SoS is on evolution of capability over time
- A functioning SoS takes start-up time but, in steady state, seems well-suited to routine incremental updates

Most military systems are part of an SoS operationally
Only by exception do we manage and engineer at SoS level

Core Elements of SoS SE

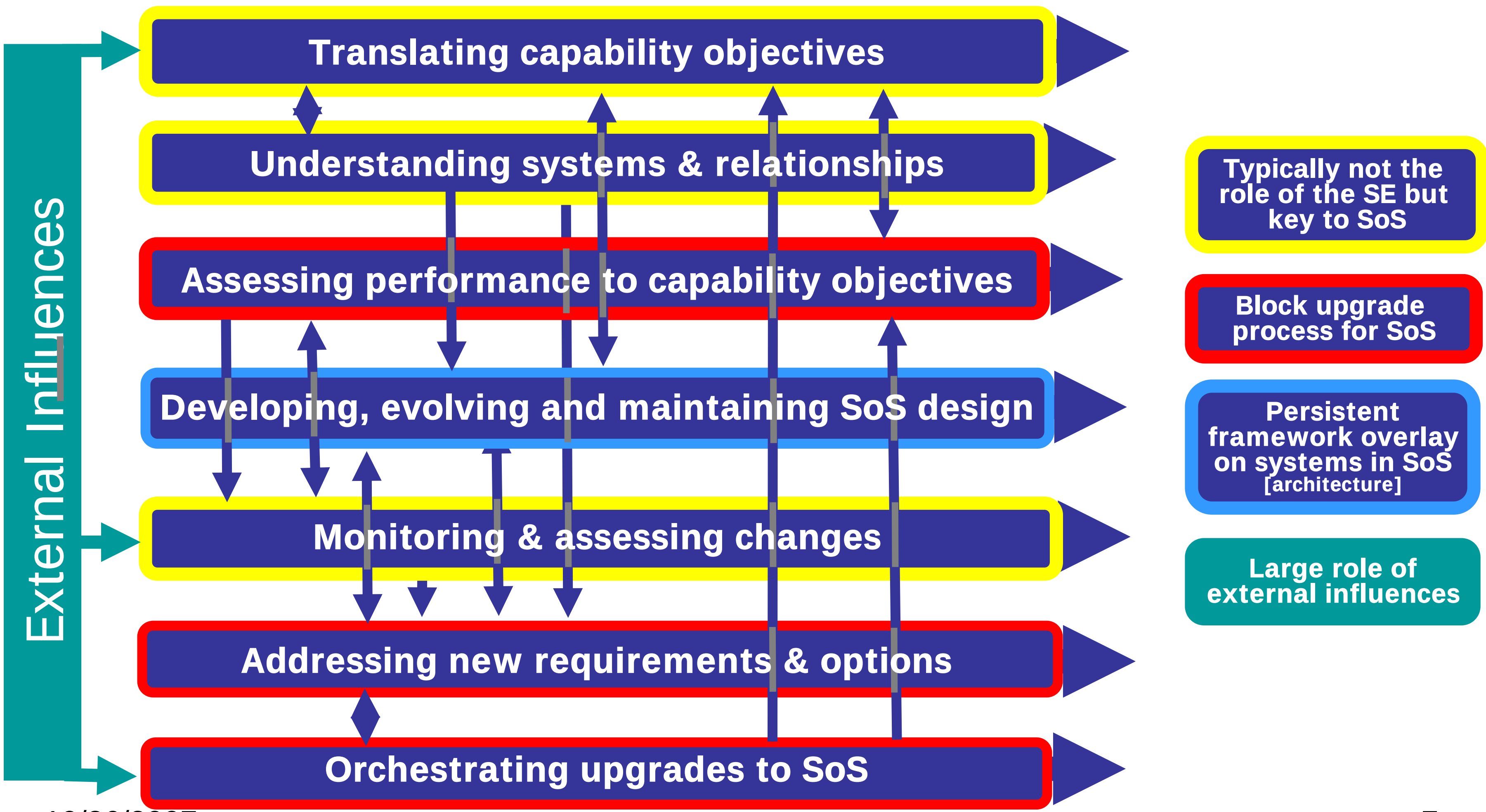
Insights From Pilots

- Translating SoS capability objectives into high level requirements over time
- Understanding the systems in the SoS and their relationships
- Assessing extent to which the SoS meets capability objectives over time
- Developing, evolving and maintaining a design for the SoS
- Anticipating and assessing impacts of potential changes on SoS performance
- Evaluating new and evolving requirements on SoS and options for addressing these
- Orchestrating upgrades to SoS

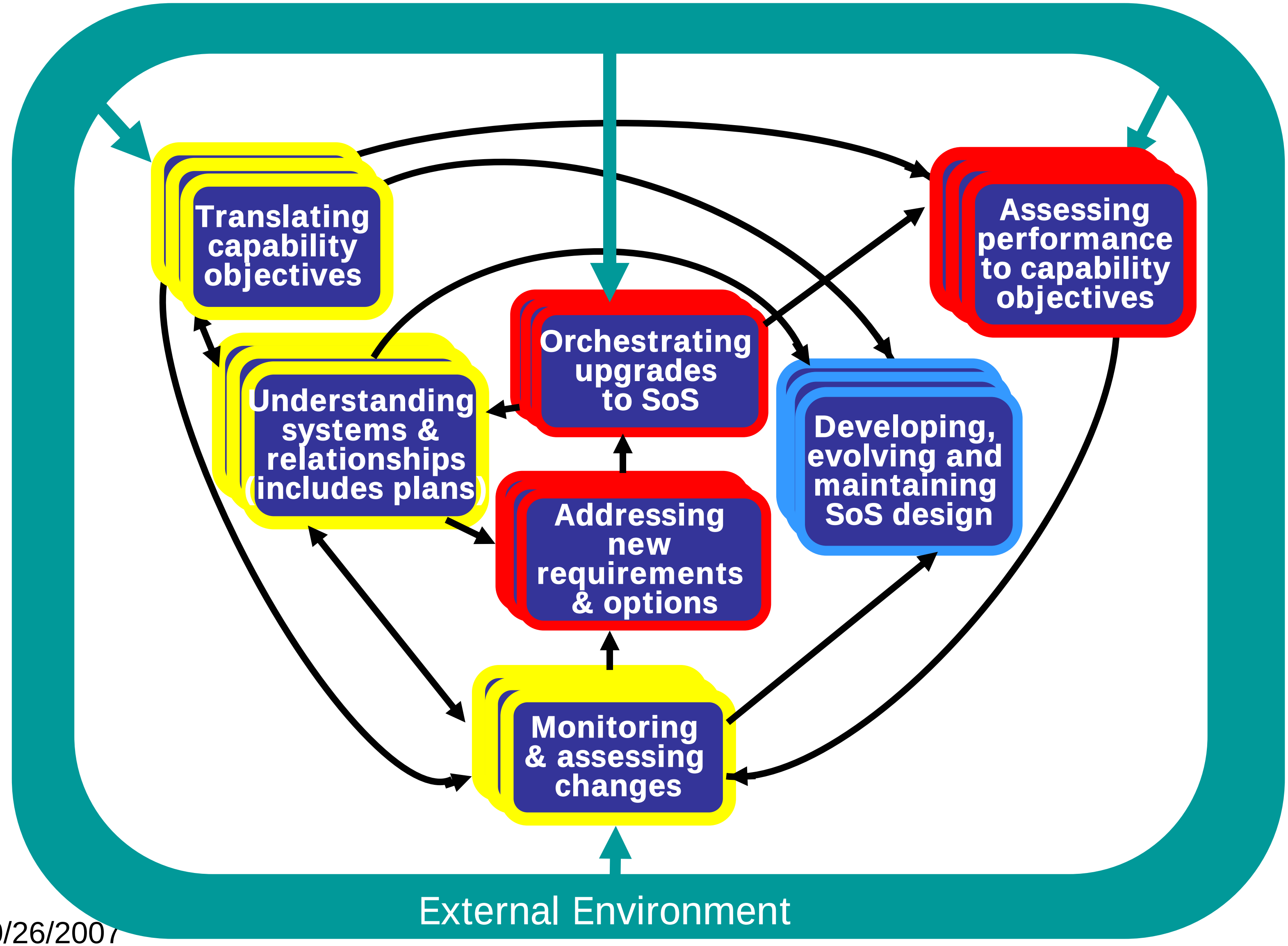
The SoS SE is responsible for creation and continual application of approaches to accomplish these elements

Relationships Among SoS SE Elements

Insights From Pilots



Relationship Among Core Elements of SoS SE



What is Working?
SoS SE Principles

Insights From Pilots

- Address organizational as well as technical perspectives
- Focus on areas critical to the SoS
  - Leave the rest (as much as possible) to the SEs of the systems
- Technical management approach reflects need for transparency and trust with focused active participation
- SoS designs are best when open and loosely coupled
  - Impinge on the existing systems as little as possible
  - Are extensible, flexible, and persistent overtime
- Continuous (‘up front’) analysis which anticipates change
  - Design strategy and trades performed upfront and throughout
  - Based on robust understanding of internal and external sources of change

Relationship to Core SE Processes

Insights From Pilots

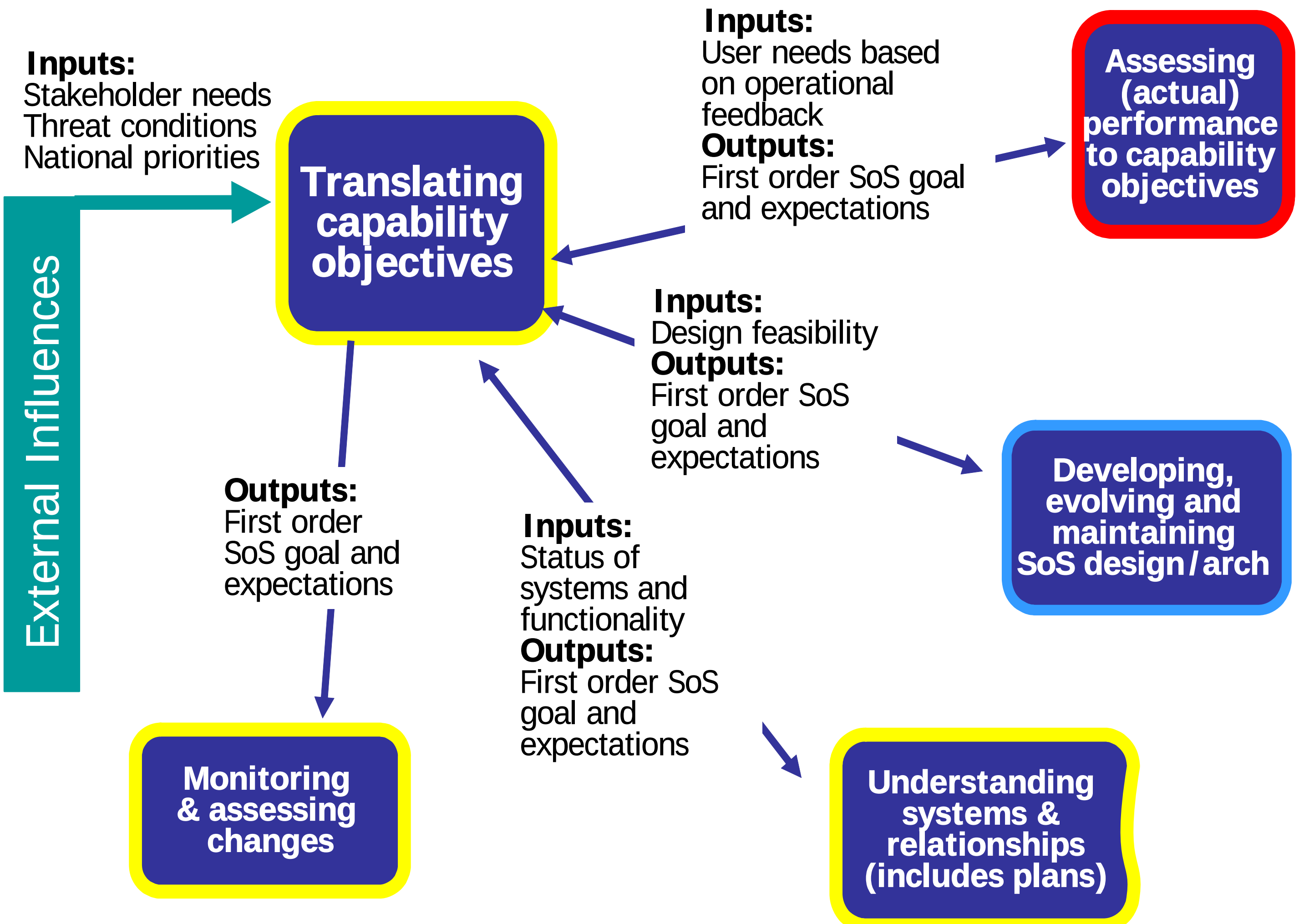
- 16 SE processes apply across the SoS SE elements
  - Offer a ‘toolbox’ to apply to SoS SE needs

	Technical Processes								Technical Management Processes							
SoS SE Elements	Rqts Devel	Logical Analysis	Design Solution	Implement	Integrate	Verify	Validate	Transition	Decision Analysis	Tech Planning	Tech Assess	Rqts Mgt	Risk Mgt	Config Mgt	Data Mgt	Interface Mgt
Translating Capability Objectives	X											X			X	
Understanding Systems and Their Relationships		X							X				X	X	X	X
Assessing Performance to Capability Objectives		X					X		X		X		X		X	
Developing, Evolving & Maintaining SoS Design	X	X	X						X	X		X	X	X	X	X
Monitoring and Assessing Changes									X				X		X	
Address New Rqts & Options to Implement	X		X						X	X		X	X		X	X
Orchestrating Upgrades				X	X	X	X	X	X	X		X	X		X	X

Reflect the fact that technical processes are primarily implemented by systems

Reflect the SoS SE role of technical coordination and direction across systems

Information Flow Among SoS SE Elements



SE Processes Supporting Each SoS SE Element

Translating Capability Objectives *(sample)*

"The **Requirements Development** process takes all inputs from relevant stakeholders and translates the inputs into technical requirements." [DAG]	• **Top level capability objectives ground the requirements for the SoS** • **In an SoS, in most cases requirements development is an ongoing process.** • **As the SoS evolves over time, needs may change. The overall mission may be stable, but the threat environment may be very different.** • **In a SoS, capability objectives may be more broadly conceived** … • …
"**Requirements Management** provides traceability back to user-defined capabilities… "[DAG]	• **The requirement management process begins with translating SoS capability objectives into high level requirements in the SOS SE process. The work in this element provides the grounding for the work done over time in defining, assessing, and prioritizing user needs for SoS capabilities.** • **.....**
"**Data management** … addresses the handling of information necessary for or associated with product development and sustainment." [DAG]	• **Translating SoS capability objectives into high level requirements is the start point of building a knowledge base to support the SoS development and evolution.** • **In this element the SE develops and retains data on the the capability needs and high level requirements for the SoS for use throughout the SoS elements**.

Comparison of Engineering Focus Areas (1 of 2)

Area	Systems	System of Systems
What to engineer	**Based on a set of functional and performance requirements for the system of interest**	• **Based on a set of SoS capabilities that are then translated into high level requirements for further analysis** • **A single capability can result in multiple requirements that affect multiple constituent systems**
View of system-of-interest	**Clear system boundaries** **Interfaces**	• **Systems that contribute to SoS capabilities and the interrelationships between those systems**
Architecture	**Developed and optimized to support single purpose of system**	• **Net-centric, focused on information sharing** • **Does not address design details within constituent systems, but rather the way the systems work together to meet user needs** • **Sufficient versus optimized**
Design approach	**Often top-down**	• **Combined top-down and bottom-up, with focus on** – **Existing assets (systems) that are within the SoS** – **Opportunities within constituent system lifecycles for changes**

Comparison of Engineering Focus Areas (2 of 2)

Area	Systems	System of Systems
Implementation	**Contract-controlled, often using an incremental, evolutionary, or spiral process** **Focus on total system**	• **SoS functionality implementation accomplished through combination of negotiation, sometimes funded by SoS or system owner, not always done via formal agreements** • **Asynchronous and incremental due to lifecycles of constituent systems** • **Primarily concerned with the implementation of SoS functionality,** • **Monitors the evolution of constituent systems to ensure that SoS is not adversely impacted, but not typically involved in the implementation details**
Testing	**Traditional testing activities, e.g., DT&E and OT&E**	• **Attempt to leverage off of constituent system testing** • **Often impossible to test full-up SoS in a lab—often rely on constituent system integration labs and operational testing** • **Operationally, looking for how users use the system and identifying emergent behavior for further analysis**

Issues to be Addressed

- Testing in a systems of systems environment
- SoS risk and cost drivers
  - Identify and plan for; mitigate interdependency risk
  - Inform leadership of risk
- Community questions
  - Should we change the way we engineer individual systems?
  - What is the role of net-centricity in SoS?
- Enablers to allow SEs to better operate in SoS environments, such as
  - Additional processes or new ways to implement current processes
  - New contracting methods
  - New models of governance

Briefed to T&E DSB

FY08 SSE Initiative

Ongoing SoS IPT Exchange

INCOSE Working Group

Summary and Discussion

- US plans to continue SoS project in FY08 and beyond
  - Publish SoS Guide Version 1.0
  - Update SE policy/guidance/training with SoS findings
  - Address open issues
  - Apply findings to program support activities
  - Apply findings to portfolio managers – C2, JNO, others

Backup Slides

Definitions

System

An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective

Mil-Std 499B

System of Systems

A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities

DoD Defense Acquisition Guide, System of Systems Engineering

System of Systems Engineering

Planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a SoS capability greater than the sum of the capabilities of the constituent parts

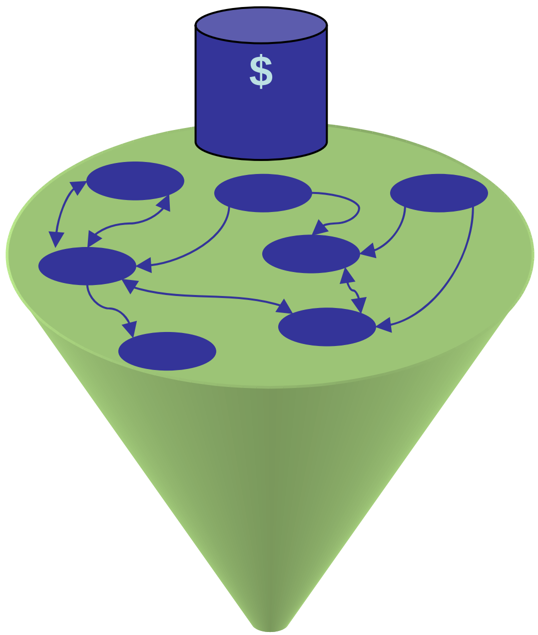
DoD Defense Acquisition Guide, Chapter 4

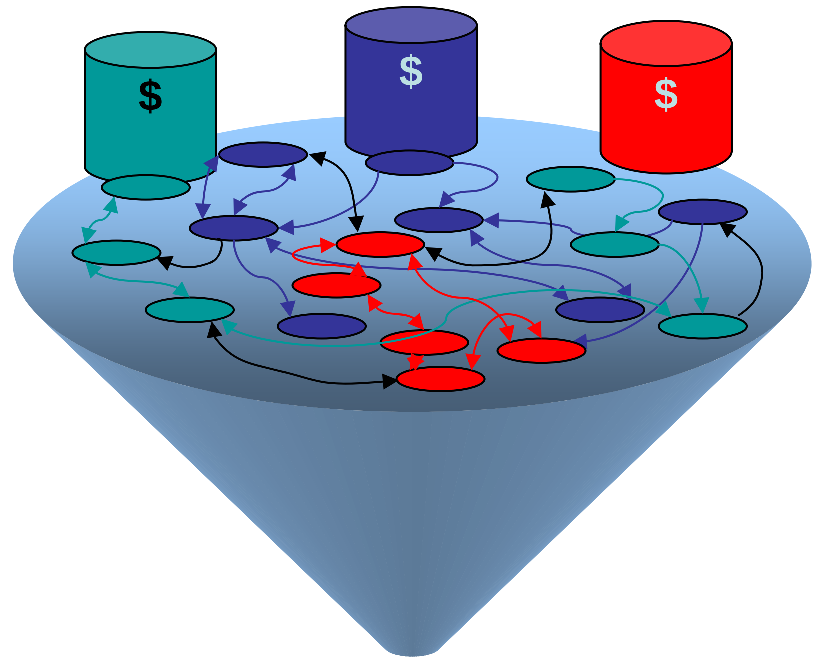
Acquiring Defense Capabilities
SoS SE Considerations

- **Ownership/Management** Individual systems are owned by the military Services or agencies
- **Legacy** Current systems will be part of the defense inventory for the long-term and need to be factored into any approach to SoS
- **Changing Operations** Changing threats and concepts mean that new (ad hoc) SoS configurations will be needed to address changing, unpredictable operational demands
- **Criticality of Software** SoS are constructed through cooperative or distributed software across systems
- **Enterprise Integration** SoS must integrate with other related capabilities and enterprise architectures
- **Portfolios** SE will provide the technical base for selecting components of the systems needed to support portfolio objectives

Capability needs will be satisfied by groupings of legacy systems, new programs, and technology insertion – Systems of Systems (SoS)

System of Systems –
The Management Challenge



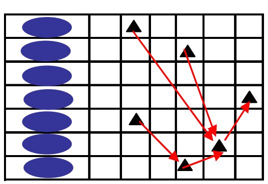


<u>SoS:</u>

Within

Single

Organization



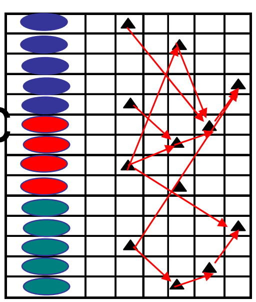
<u>Joint SoS:</u>

Interdependenc
ies

Across

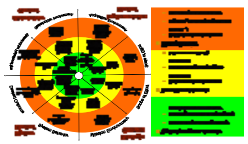
Multiple

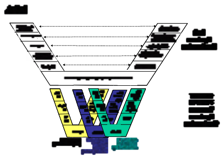
Organizations



Political and Cost Considerations Impact on Technical Issues

Initial Pilot Results





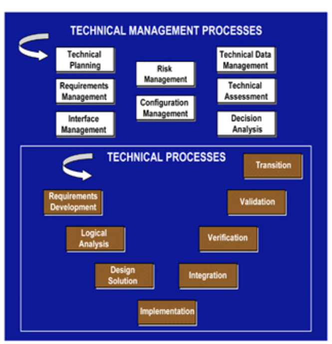
- **Wide range of views on the SoS depictions**
  - Still sorting out a good approach, inputs welcome
  - Most felt current depictions did not adequately portray the dynamics and complexity faced in SoS SE

21	Systems	Systems of Systems
Community Involvement		
Stakeholder Involvement	• Stakeholders generally committed only to the one system	• Stakeholders more diverse; • Stakeholders from each system will have some interest in the other systems comprising the SoS • Dynamic involvement (e.g. high turnover)
Governance	• Single PM and funding	• Multiple PMs for constituent systems with separate authorities and funding • Wider collaboration
Operational Environment		
Mission Environment	• Mission environment is relatively stable, pre-defined, and generally well-known	• Emphasis on multiple missions, integration across missions,
Operational Focus	• Operational focus is clear	• Need for ad hoc operational capabilities to support rapidly evolving mission objectives • Asset management of diverse configurations
Implementation		
Acquisition/Test & Validate	• Aligned to ACAT Milestones, specified requirements, a single DoD PM, SE with a Systems Engineering Plan (SEP) • Test and validating the system is possible	• Multiple system lifecycles across acquisition programs, involving legacy systems, developmental systems, and technology insertion with multiple DoD PEOs, PMs and operational and support communities • Testing is more difficult, and test and validation can be distributed and federated
Engineering		
Boundaries, Interfaces, and Performance & Behavior	• Clear external boundaries • Interface management under single control • Autonomous behavior with defined dependencies	• Product of multiple systems, evolving asynchronously • Interoperability key for SoS • Ambiguity in membership and boundaries

- **General agreement on Systems vs SoS distinctions**
  - Need for more careful wording
  - Particular need to clarify discussion of ‘stakeholders’

Gap!

- **Most felt that the guide needed an explicit discussion of SoS and SoS SE in the DoD today**
  - Need to describe the elements of SoS SE and clearly differentiate between the role of the SoS SE and the System SEs in SoS
  - Provide context for discussion of 16 processes



- **16 SE processes**
  - General agreement that these apply to SoS and with the thrust of the discussion on each process
  - Need to clarify how these are implemented at the SoS and how these relate to the same processes for the systems
- **Guide too long and hard to use**

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

System of Systems Engineering Pilot Quality Function Deployment Analysis

10th Annual Systems Engineering Conference
22-25 October, 2007

Paper No. 5602

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Version dated 10/12/07

Introduction

- SoS Systems Engineering project addressing LCS ASW Integration & Mission Capability Evolution
- Pilot project conducted by ASW Systems Engineering Team (ASSET) chaired by PEO-IWS5 SE
- Application of ASN/RDA CHSENG Naval SoS SE Guidelines
- Employed Quality Function Deployment (QFD) for SoS capability evaluation

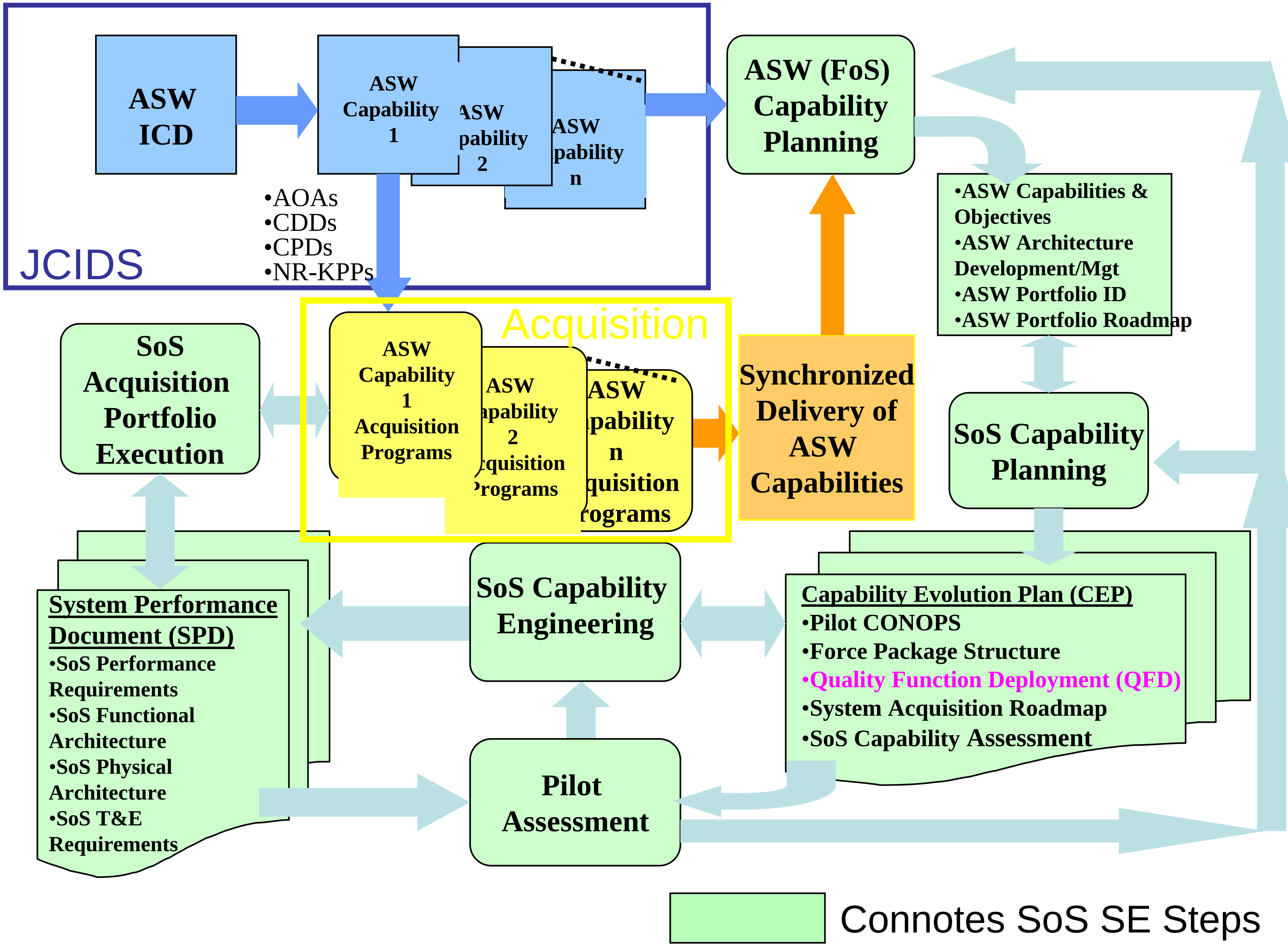
LCS ASW SoS Pilot Project

- Proliferation of quiet diesel submarines creates a growing ASW challenge
- ASW inherently a “system-of-systems” enterprise:
    - Platforms
    - Sensors
    - Weapons
    - Command, Control & Communications
- Littoral Combat Ship (LCS) a “transformational” concept:
    - Agile platform
    - Reconfigurable mission packages
    - Extensive use of unmanned vehicles & off-board sensors
    - Spiral development
- Pilot project objectives
    - Address needed ASW capability
    - Apply ASN/RDA SoS SE guidelines
        - Including QFD
    - Show “value added” in SoS acquisition

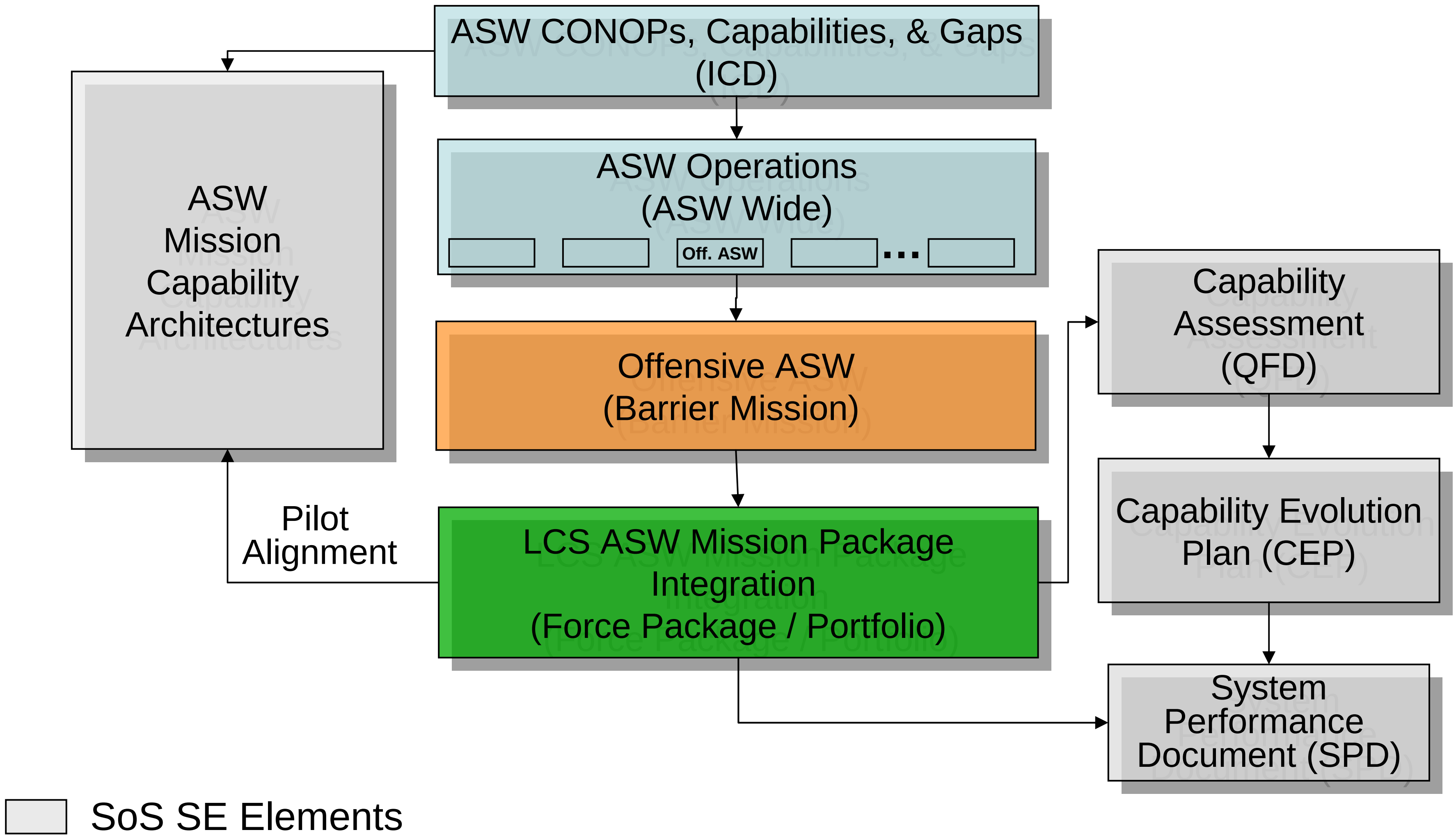
Quiet Diesel Submarine Threat

LCS Platform Concepts

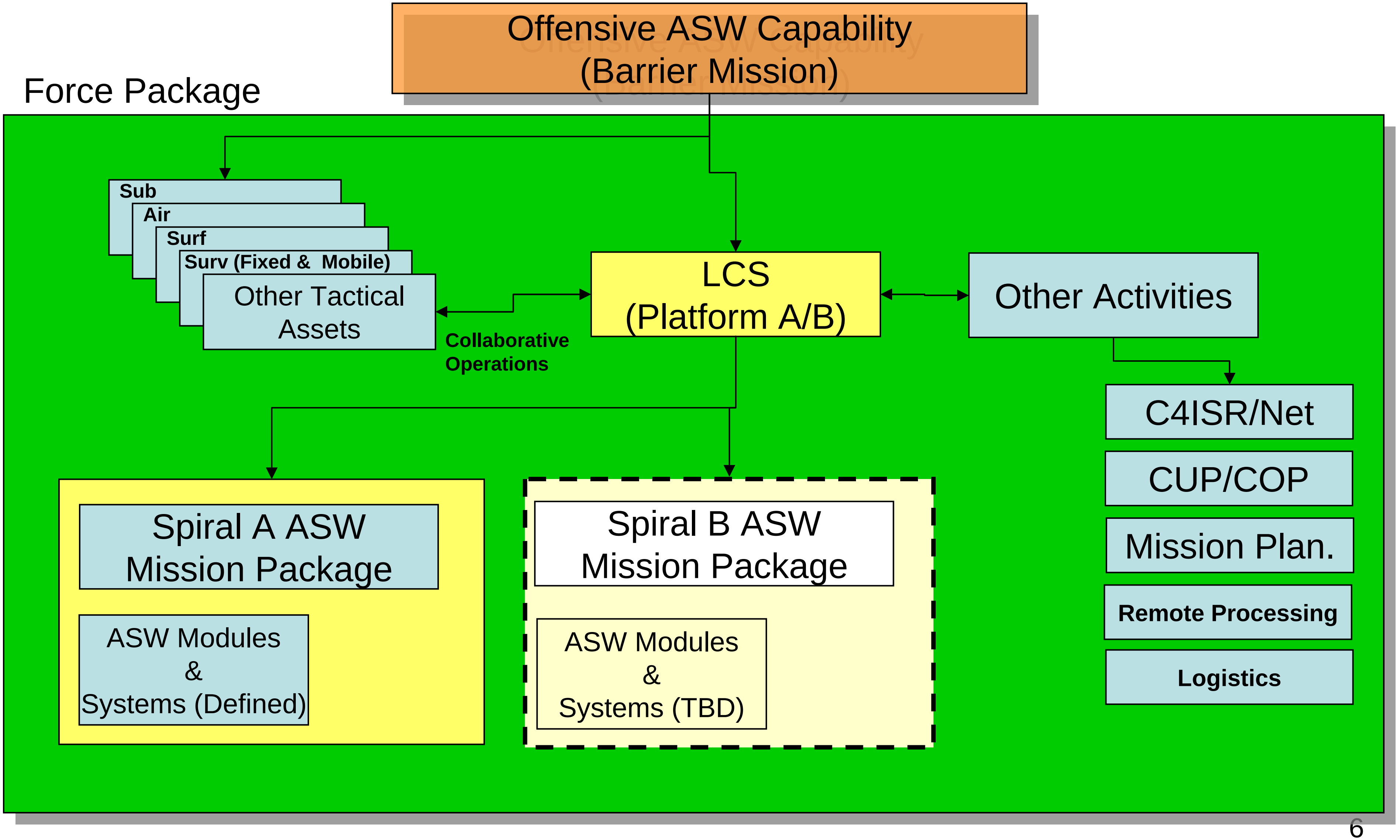
ASW System of Systems Engineering Process



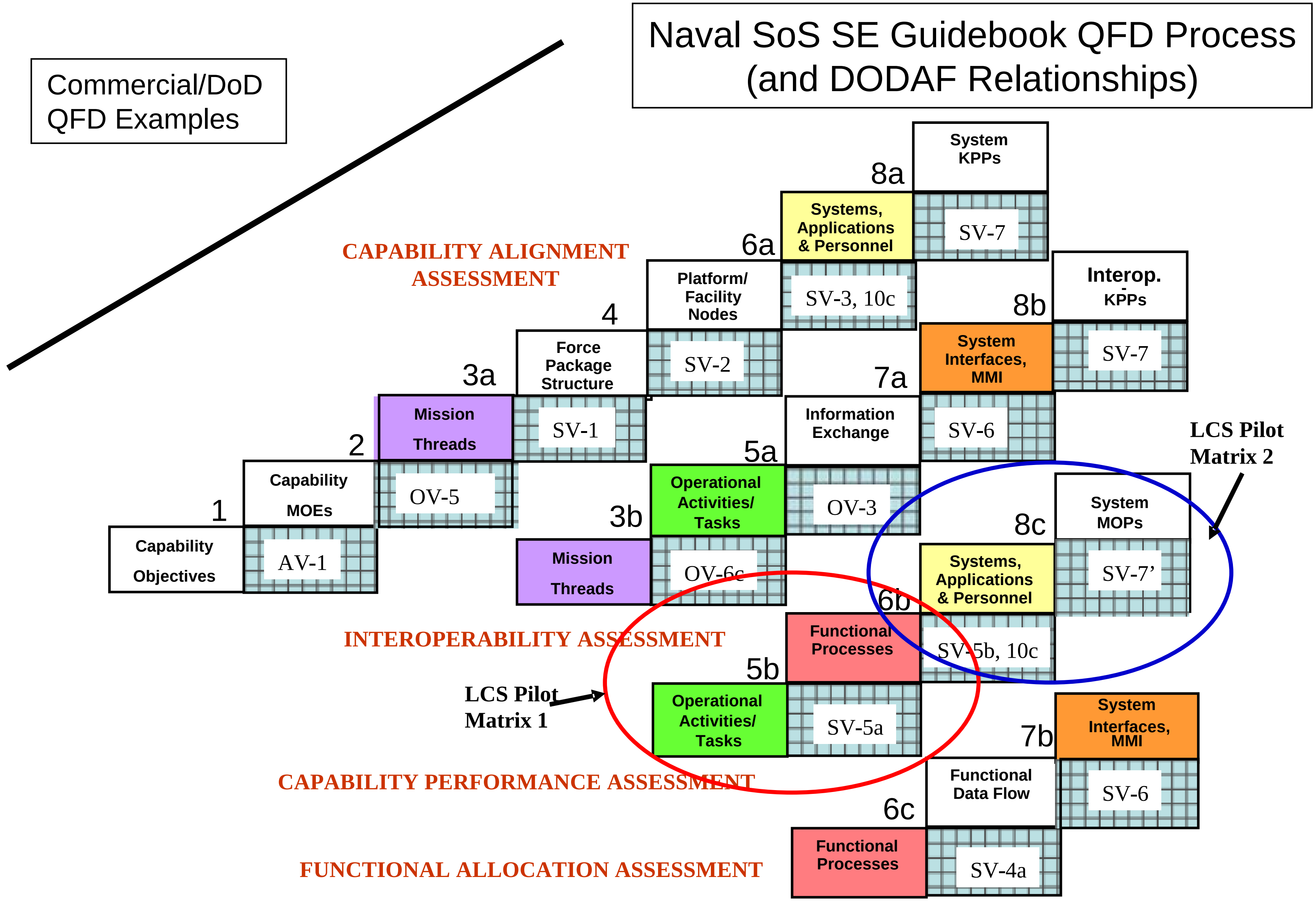
LCS ASW Mission Context



LCS Pilot Project Portfolio



QFD Matrices for Capability-Based Planning



Pilot QFD Matrices & Workshop

Mission & SoS Systems MCA

Matrix 1

Operational Stages and Activities

SoS Functions & Systems

Operational Priority and Functional & System Importance

Importance Score

Workshop Day 1

Critical Functions

Operational & Engineering Metrics (ICD, CDD, Other)

Matrix 2

SoS System Functions & Systems

SoS Capability Metrics

Functional Capability Assessment

Capability Score

Workshop Day 2

SoS Capability "Gaps" (CEP Focus)

- 2-Day Workshop
- ~30 Subject Matter Experts (SME)
- Divided into four teams
- Operational, technical, engineering expertise

Matrix 1 (partial)

Operational Activity & System Functions

Step 1: Allocation of 1000 points across stages and activities

LCS Pilot SoS System and Functions

Operational Stage

Operational Activities

					Platform / Vehicle	1.1.1 Helicopter																	
					System	1.1.1.1 Helo (SH-60B, MH-60R)				1.1.1.2 ALFS (Dipping Sonar) (MH60R Only)				1.1.1.3 Sonobuoy (Family)					1.1.1.4 MAD, Radar, EO (Helo Dependent)	1.1.1.5 Weapons (Mk46, MK54)			
					ID	F1.1.1.1.1	F1.1.1.1.2	F1.1.1.1.3	F1.1.1.1.4	F1.1.1.2.1	F1.1.1.2.2	F1.1.1.2.3	F1.1.1.2.4	F1.1.1.3.1	F1.1.1.3.2	F1.1.1.3.3	F1.1.1.3.4	F1.1.1.3.5	F1.1.1.4.1	F1.1.1.5.1	F1.1.1.5.2	F1.1.1.5.3	F1.1.1.5.4
Stage	Stage Score	ID	Activity	Stage Score Allocations	Functions:	Flight operations	Communicate	Sensor Processing	Navigation	Deploy	Sense	Localize	Onboard Processing	Deploy	Sense	Localize	Onboard Processing	Communicate	DCL	Deploy / Placement	Search	Acquire Target	Kill
A. Storage	0	A.1	Retrieve MP from Stowage																				
		A.2	Module configuration and checkout																				
		A.3	Transport																				
		A.4	Onload modules and mission crew																				
B. Deployment	0	B.1	Assign Mission																				
		B.2	Plan ASW mission																				
		B.3	Underway and Transit																				
		B.4	Arrive at assigned operating area																				
		B.5	Establish theater tactical communications (OPCON and TACON)																				
		B.6	Coordinate with other assets																				
C. Installation	0	C.1	Arrive OPAREA																				
		C.2	Characterize/measure area environment																				
		C.3	Mission/Sensor employment planning																				
		C.4	Final vehicle/sensor reconfiguration and checkout																				
		C.5	Launch vehicles/OOV's																				
		C.6	Check operability																				
		C.7	Return to patrol station																				
		C.8	Operate and monitor OOV's																				
					Metric Score	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

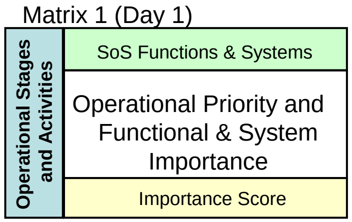
Function Importance

Step 2: Score in terms of criticality of function to operational activity (scale: 9-6-3-1, 0)

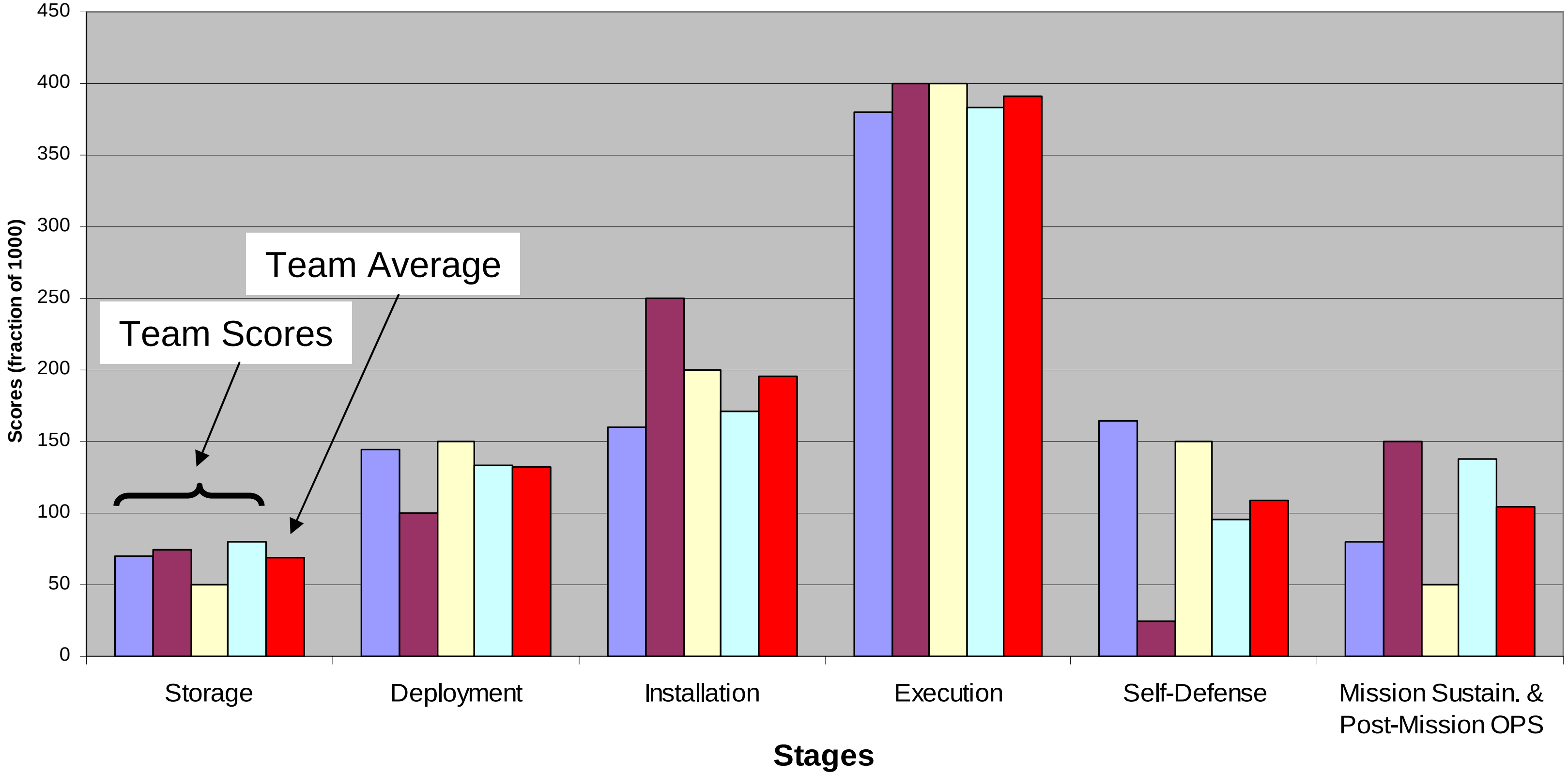
Step 3: Compute overall Importance Score

Importance score = Σ (Activity value X criticality value per cell)

Additional Matrix Rows & Columns



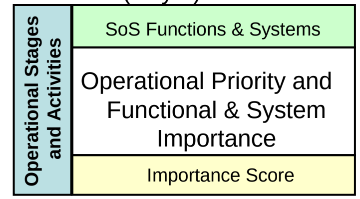
Stage Score Allocations (Matrix 1)



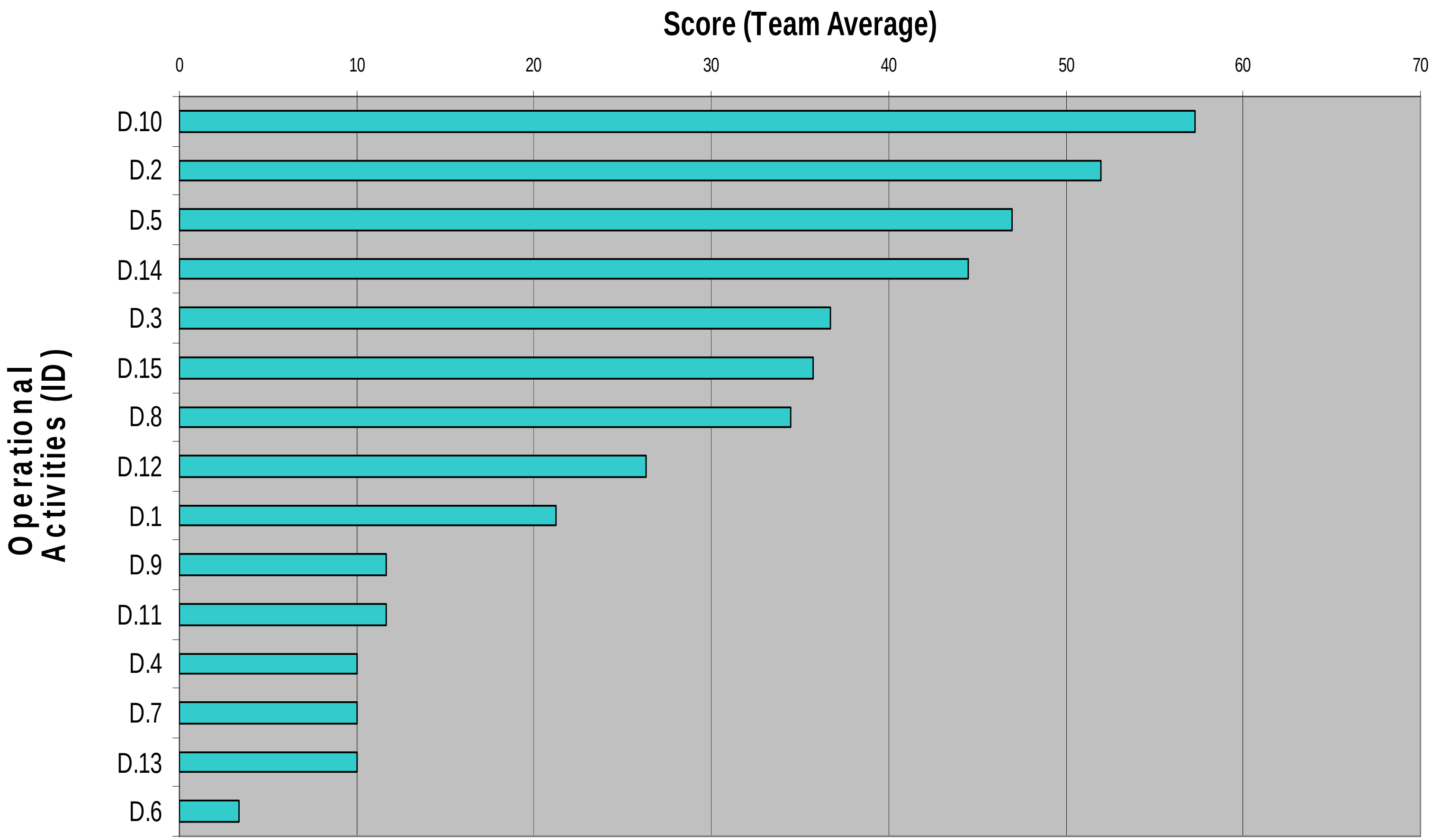
Team prioritization of operational the six stages
(Allocation of 1000 points)

Operational Activity Priority – *Execution Stage*
Rank Ordered Team Averages

Matrix 1 (Day 1)

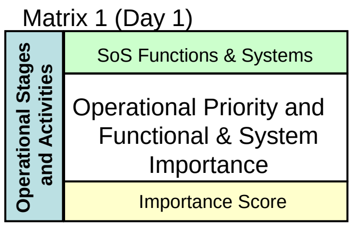


(Allocation of points assigned to Execution Stage)



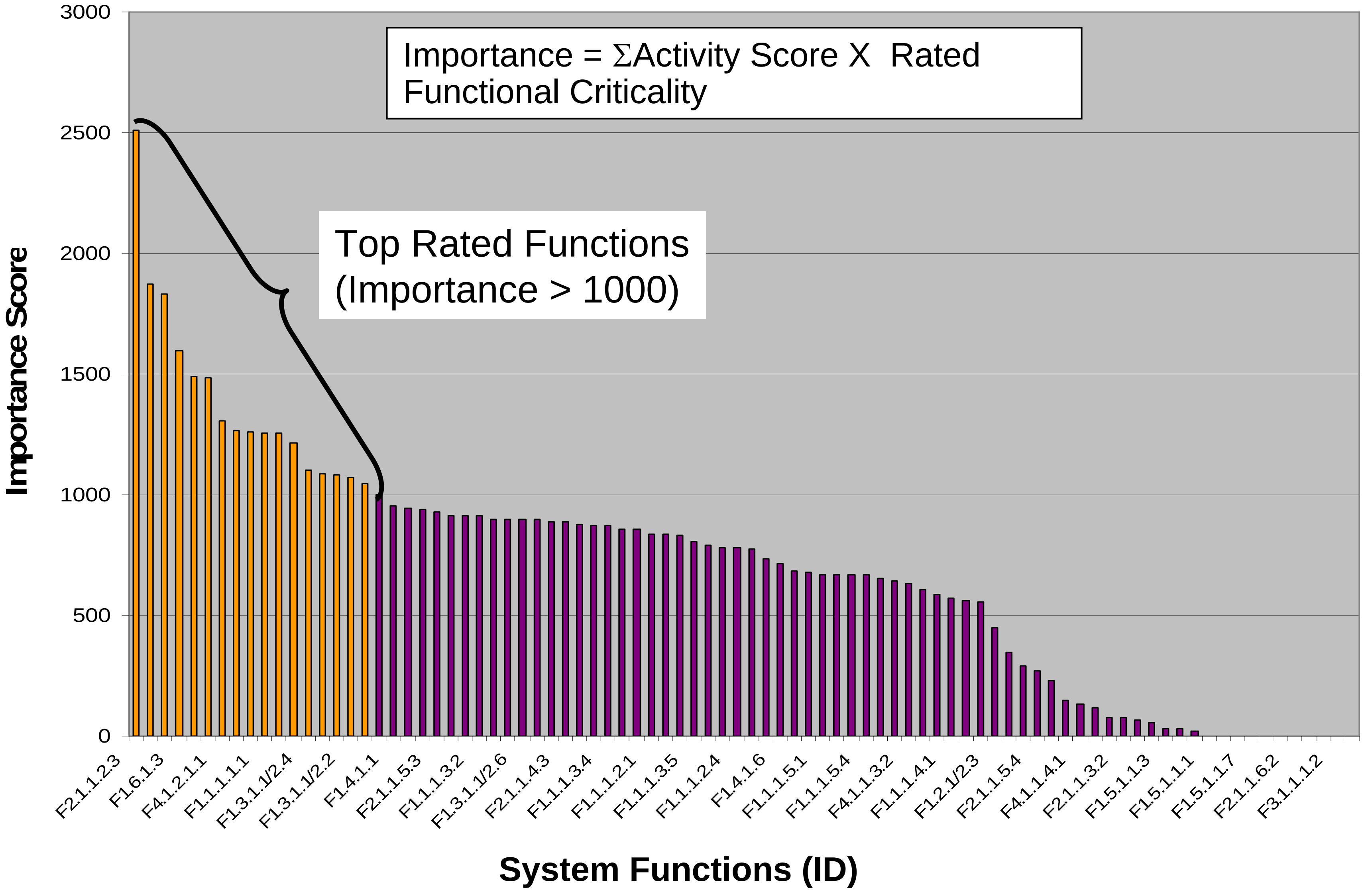
Lower Priority

Higher Priority



Function Importance (Execution Stage/Matrix 1)

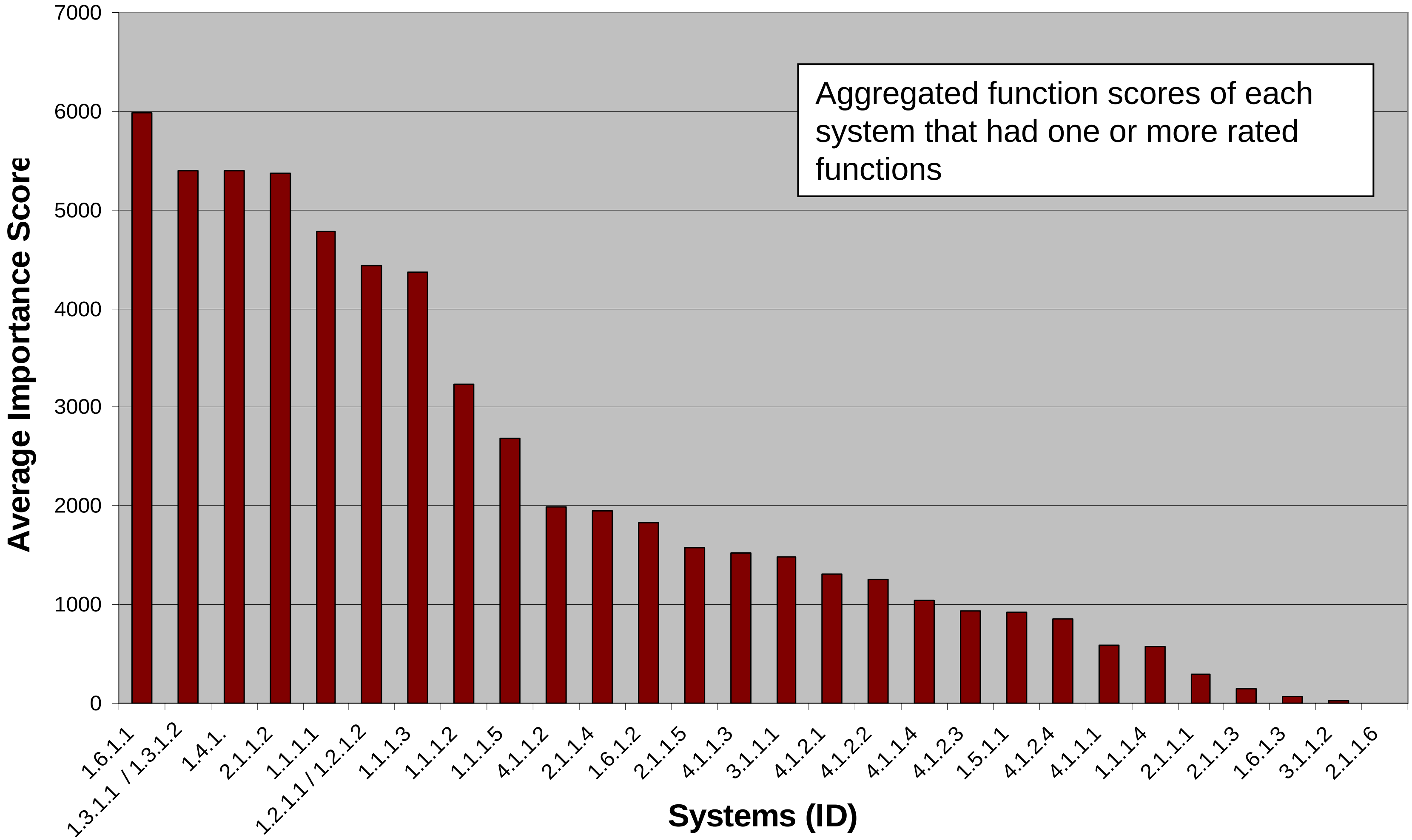
Team Score Averages (Ranked)



Matrix 1 (Day 1)

Operational Stages and Activities	SoS Functions & Systems
	Operational Priority and Functional & System Importance
	Importance Score

System Importance (Matrix 1) Execution Stage Ranked Team Averages



Matrix 2 (Day 2)

SoS System Functions & Systems

SoS Capability Metrics

Functional Capability Scoring

Capability Score

Matrix 2 (partial)

System/Functions vs Capability

Step 1: Address higher important functions and systems from Matrix 1

Capability Metrics (by Category)

System and Functions (from Matrix 1)

Global Metric	M1.1 ASW Search						M1.2 Kill Chain Metrics					
ID	M1.1.1	M1.1.2	M1.1.3	M1.1.4	M1.1.5	M1.1.6	M1.2.1	M1.2.2	M1.2.3	M1.2.4	M1.2.5	M1.2.6
Metric	Search Rate/Coverage	Detect/Class	Track	False Contact Rate	LCS Mission Sustainment (days)	Area Environmental Understanding	Redetect & Class	Localize	Engage	Kill	Asset Availability/Responsiveness	Weapon Availability
Score	0	0	0	0	0	0	0	0	0	0	0	0

Functional Component	Platform / Vehicle	System	ID	Functions:	Metric Score (from Matrix #1)
1.1 Aviation Mission Module	1.1.1 Helicopter	1.1.1.1 Helo (SH-60B, MH-60R)	F1.1.1.1.1	Flight operations	0
			F1.1.1.1.2	Communicate	0
			F1.1.1.1.3	Sensor Processing	0
			F1.1.1.1.4	Navigation	0
		1.1.1.2 ALFS (Dipping Sonar) (MH60R Only)	F1.1.1.2.1	Deploy	0
			F1.1.1.2.2	Sense	0
			F1.1.1.2.3	Localize	0
			F1.1.1.2.4	Onboard Processing	0
		1.1.1.3 Sonobuoy (Family)	F1.1.1.3.1	Deploy	0
			F1.1.1.3.2	Sense	0
			F1.1.1.3.3	Localize	0
			F1.1.1.3.4	Onboard Processing	0
			F1.1.1.3.5	Communicate	0
		1.1.1.4 MAD, Radar, EO (Helo Dependent)	F1.1.1.4.1	Detect/Classify/Localize	0
		1.1.1.5 Weapons (Mk46, MK54)	F1.1.1.5.1	Deploy / Placement	0
			F1.1.1.5.2	Search	0
			F1.1.1.5.3	Acquire Target	0
			F1.1.1.5.4	Kill	0
1.2 Mid-Frequency Bistatic Mission module	1.2.1 RMV(2)	1.2.1.1 RTA / 1.2.1.2 RTAS	F1.2.1/2.1	Operate & Control	0
			F1.2.1/2.2	Sense	0
			F1.2.1/2.3	Localize / Track	0
			F1.2.1/2.4	Communicate	0
			F1.2.1/2.5	Onboard Processing	0
			F1.2.1/2.6	Navigate	0
1.3 LF Bistatic Mission Module	1.3.1/ 1.4.1 USV(2)	1.3.1.1 UTAS / 1.3.1.2 MSOBS	F1.3.1.1/2.1	Operate & Control	0
			F1.3.1.1/2.2	Sense	0
			F1.3.1.1/2.3	Localize / Track	0
			F1.3.1.1/2.4	Communicate	0
			F1.3.1.1/2.5	Status / Diagnostics	0
			F1.3.1.1/2.6	Navigate	0
1.4 Mid-Frequency Monostatic Mission Module		1.4.1. UDS	F1.4.1.1	Operate & Control	0
			F1.4.1.2	Sense	0
			F1.4.1.3	Localize / track	0
			F1.4.1.4	Communicate	0
			F1.4.1.5	Navigate	0
			F1.4.1.6	Onboard Processing	0

System Capability Score

Overall Capability Score

Step 2: Score in terms of capability (fully capable to significantly incapable)

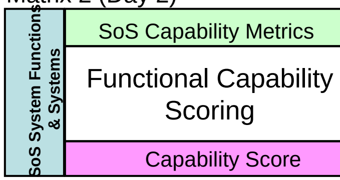
Step 3: Compile overall capability scores

Additional Matrix Rows & Columns

Score = Σ (system function score X adequacy rating value per cell)

Capability Scores
(Execution Stage)

Matrix 2 (Day 2)



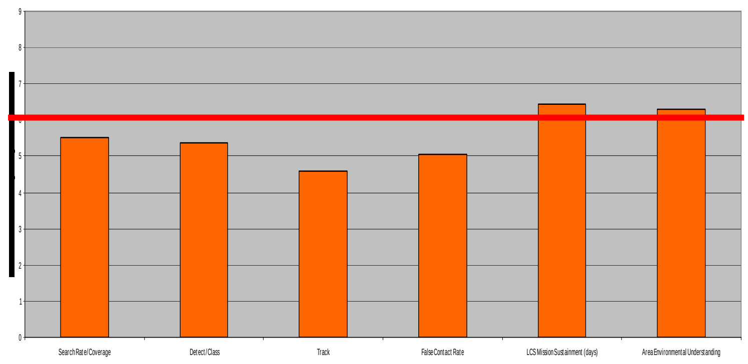
Search

Fully Capable

Moderately Capable

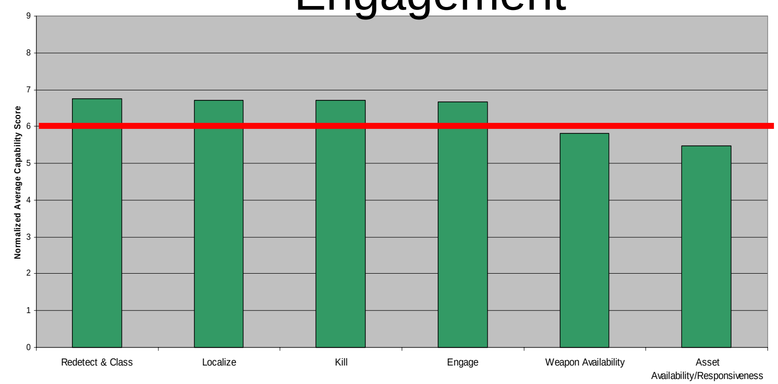
Moderately Inadequate

Completely Inadequate



Capabilities

Engagement



Capabilities

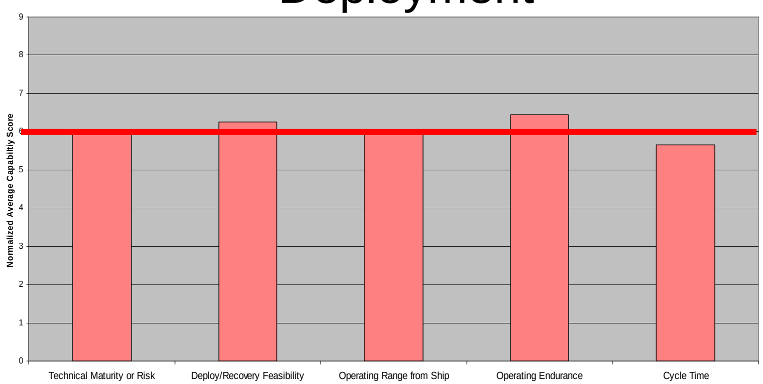
Deployment

Fully Capable

Moderately Capable

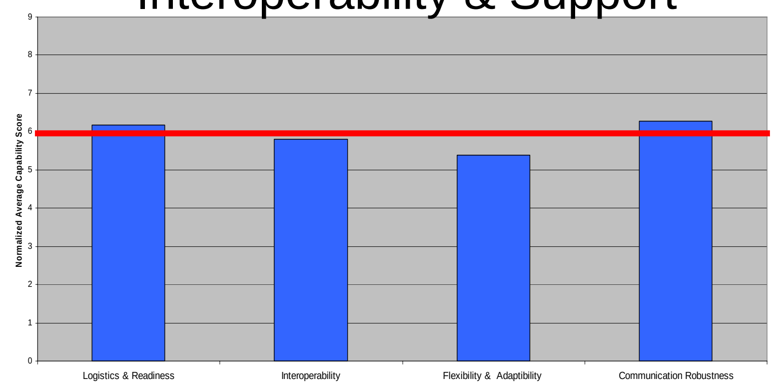
Moderately Inadequate

Completely Inadequate



Capabilities

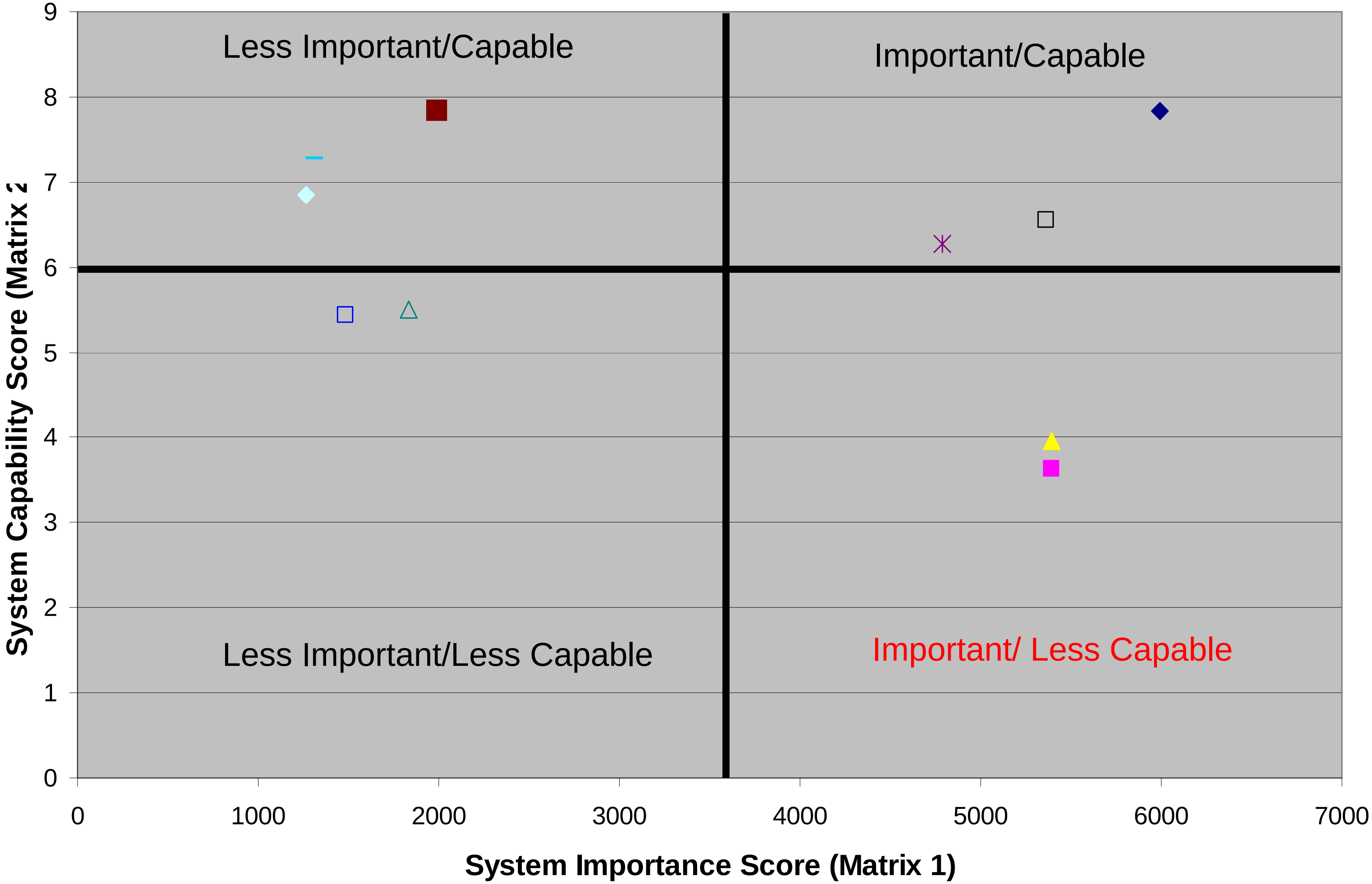
Interoperability & Support



Capabilities

Score < 6 considered a Capability “gap”

System Capability vs. Importance (Results of Matrix 1 & 2)



(Based on Execution Stage evaluation)

QFD Workshop Comments

- Carefully constructed matrices critical to success
- Manageable matrix size (dimensions)
- A two-day workshop was insufficient
- Dividing participants into four smaller working groups worked well.
- Need clear Concept of Operations and mission threads (ideally an approved set of architectures)
- Description and performance information regarding the systems being rated needed on site
- An experienced QFD workshop facilitator if not facility recommended

Summary

- LCS ASW Integration Pilot project has been a good example of SoS SE process
  - Portfolio of systems
  - Application of the ASN/RDA SoS SE Guidelines
- The QFD process was adapted from the SoS SE Guide and other QFD applications and was effective in identifying functional priorities and capability gaps across a complex SoS portfolio.
- QFD matrices must be customized to assess the operational, functional, and physical aspects of the Force Package.
- The matrices map to or expand upon the DOD Architecture Framework and thereby are a further use of the architecture products
- The process followed is considered useful, applicable, and adaptable to other SoS capability evolution scenarios.

Backups

LCS Operational Stages and Activities (Matrix 1)

Stage	Activity
Storage	
	Module configuration and checkout
	Transport
	Onload modules and mission crew

Stage	Activity
Deployment:	
	Plan ASW mission
	Underway and Transit
	Arrive at assigned operating area
	Establish theater tactical communications (OPCON and TACON)
	Coordinate with other assets

Stage	Activity
Installation	
	Characterize/measure area environment
	Mission/Sensor employment planning
	Final vehicle/sensor reconfiguration and checkout
	Launch vehicles/OOV's
	Check operability
	Return to patrol station
	Operate and monitor OOV's

Stage	Activity
Execution	Conduct area search
	Detect and classify contacts
	Resolve possible false contacts
	Report detections to Sqn and ASWC
	Localize, track and monitor threat submarines
	Target reported to sqn and ASWC
	Prosecution assets proceed to target
	Prosecution assets redetects, classifies and localizes target
	Prosecution assets request and receives attack authorization
	Prosection assets launches weapon
	Attack assessment
	Reattack if required
	Prosecution assets return to LCs or patrol station
	Handoff/receive targets with other assets
	Maintain tactical Picture

Stage	Activity
Self-Defense	Threat /Weapons DCL
	Evade

Stage	Activity
Mission Sustainment & Post-Mission OPS	Refurbish and Redeploy OOV's
	LCS proceeds to sensor station
	Final recovery of OOV's
	Conducts turnover with relieving LCS
	Onboard stowage
	Transit to port (or ship replenishment sight)
	Off-load
	Refurbishment
	Stowage

*Ref: LCS ASW Mission Package Overview, PMS 420

**Ref: LCS Operational Assessment Scenario, SPA and other sources

LCS ASW SoS Pilot
System and Functions (Matrix 1 & 2)

1. OOV/Sensors

1.1.1 Helicopter																	
1.1.1.1 Helo (SH-60B, MH-60R)				1.1.1.2 ALFS (Dipping Sonar) (MH60R Only)				1.1.1.3 Sonobuoy (Family)					1.1.1.4 MAD, Radar, EO (Helo Dependent)	1.1.1.5 Weapons (Mk46, MK54)			
F1.1.1.1.1	F1.1.1.1.2	F1.1.1.1.3	F1.1.1.1.4	F1.1.1.2.1	F1.1.1.2.2	F1.1.1.2.3	F1.1.1.2.4	F1.1.1.3.1	F1.1.1.3.2	F1.1.1.3.3	F1.1.1.3.4	F1.1.1.3.5	F1.1.1.4.1	F1.1.1.5.1	F1.1.1.5.2	F1.1.1.5.3	F1.1.1.5.4
Flight operations	Communicate	Sensor Processing	Navigation	Deploy	Sense	Localize	Onboard Processing	Deploy	Sense	Localize	Onboard Processing	Communicate	DCL	Deploy / Placement	Search	Acquire Target	Kill

1.2 Mid-Frequency Bistatic Mission module						1.3 LF Bistatic Mission Module						1.4 Mid-Frequency Monostatic Mission Module						1.5 UAV Mission Module							1.6 Mission Package Support						
1.2.1 RMV(2)						1.3.1/ 1.4.1 USV(2)												1.5.1 VTUAV							1.6.1 MPSE/COMMS/Storage						
1.2.1.1 RTA / 1.2.1.2 RTAS						1.3.1.1 UTAS / 1.3.1.2 MSOBS						1.4.1. UDS						1.5.1.1 VTUAV Payload							1.6.1.1 MPCE					1.6.1.2 OOV COMMS	1.6.1.3 Storage
F1.2.1/2.1	F1.2.1/2.2	F1.2.1/2.3	F1.2.1/2.4	F1.2.1/2.5	F1.2.1/2.6	F1.3.1.1/2.1	F1.3.1.1/2.2	F1.3.1.1/2.3	F1.3.1.1/2.4	F1.3.1.1/2.5	F1.3.1.1/2.6	F1.4.1.1	F1.4.1.2	F1.4.1.3	F1.4.1.4	F1.4.1.5	F1.4.1.6	F1.5.1.1.1	F1.5.1.1.2	F1.5.1.1.3	F1.5.1.1.4	F1.5.1.1.5	F1.5.1.1.6	F1.5.1.1.7	F1.6.1.1	F1.6.1.2	F1.6.1.3	F1.6.1.4	F1.6.1.5	F1.6.1.2.1	F1.6.1.3.1
Operate & Control	Sense	Localize / Track	Communicate	Onboard Processing	Navigate	Operate & Control	Sense	Localize / Track	Communicate	Status / Diagnostics	Navigate	Operate & Control	Sense	Localize / track	Communicate	Navigate	Onboard Processing	Operate & Control	Communicate/ Relay	Sense	Classify	Localize	Attack?	BDA	Data Fusion & Contact Management	CAUSS	Display	Mission Planning	Sonar Operations	Control & Data Links	Weapons, HAZMAT, CPG

2. Host Platform

2.1.1.1 Crew	2.1.1.2 Communications (Various Radios & Nets))				2.1.1.3 MS Handling Systems		2.1.1.4 Mission Package Support Equipment					2.1.1.5 Command & Control				2.1.1.6 Ship Defense			
F2.1.1.1.1	F2.1.1.2.1	F2.1.1.2.2	F2.1.1.2.3	F2.1.1.2.4	F2.1.1.3.1	F2.1.1.3.2	F2.1.1.4.1	F2.1.1.4.2	F2.1.1.4.3	F2.1.1.4.4	F2.1.1.4.5	F2.1.1.5.1	F2.1.1.5.2	F2.1.1.5.3	F2.1.1.5.4	F2.1.1.6.1	F2.1.1.6.2	F2.1.1.6.3	F2.1.1.6.4
Ship Operations	Ship-Ship	Ship-to-Shore	Ship to Off-Board Systems	Ship to Force ASW Assets	MM Deploy Crew	Deploy/Recover MM	MP Control	Data Processing	Display	Mission Planning	Test MP	Mission Planning	Env. Data Gathering	Coordination	Common Processing	Weapon DCL	Counter	Evade	Mission recovery

3.1 Maintenance and Storage			
3.1.1 MP Shore/IMA/Depot			
3.1.1.1 MP Shore/IMA			3.1.1.2 Depot & OEM
F3.1.1.1.1	F3.1.1.1.2	F3.1.1.1.3	F3.1.1.2.1
Train MP personnel	Store & Maintain Equip	Transport MP Equipment	Accept & Refurb Equip

4. Theater Assets

4.1.1 CSG/ESG Platforms								4.1.2 Other Assets			
4.1.1.1 Network (GIG/ForceNet)	4.1.1.2 ASW Command & Control		4.1.1.3 Common Picture		4.1.1.4 Mission Planning			4.1.2.1 P8-A, P3-C	4.1.2.2 Force Helo's	4.1.2.3 Other ASW Assets	4.1.2.4 Theater ISR
F41.1.1.1	F4.1.1.2.1	F4.1.1.2.2	F4.1.1.3.1	F4.1.1.3.2	F4.1.1.4.1	F4.1.1.4.2	F4.1.1.4.3	F4.1.2.1.1	F4.1.2.2.1	F4.1.2.3.1	F4.1.2.4.1
Communications	ASWC	TASW	Common Tactical Picture	Common Operational Picture	Area assignment	Sensor employment	Mutual Interfeerence	Cooperative ASW	Cooperative ASW	Cooperative ASW	Cueing

Capability Performance Metrics (Matrix #2)

M1.1 ASW Search						M1.2 Kill Chain Metrics					
M1.1.1	M1.1.2	M1.1.3	M1.1.4	M1.1.5	M1.1.6	M1.2.1	M1.2.2	M1.2.3	M1.2.4	M1.2.5	M1.2.6
Search Rate/Coverage	Detect/Class	Track	False Contact Rate	LCS Mission Sustainment (days)	Area Environmental Understanding	Redetect & Class	Localize	Engage	Kill	Asset Availability/Responsiveness	Weapon Availability

M2 System Employment Metrics					M3 SOS Metrics			
M2.1	M2.2	M2.3	M2.4	M2.5	M3.1	M3.2	M3.3	M3.4
Deploy/Recovery Feasibility	Operating Endurance	Cycle Time	Operating Range from Ship	Technical Maturity or Risk	Communication Robustness	Interoperability	Flexibility & Adaptibility	Logistics & Readiness

SYSTEM ENGINEERING AND SOFTWARE EXCEPTION HANDLING

Herb Hecht

SoHaR Incorporated

Culver City, California

WHY WE ARE HERE

1. Many failures in critical systems are due to missing or faulty exception handling
   and we want to change that
2. They were not tested under the exception conditions
3. The requirements were not specific about exceptions that had to be tolerated
4. Comprehensive specification of exceptions that have to be tolerated is difficult – or is it impossible?

HOW SOFTWARE FAILS

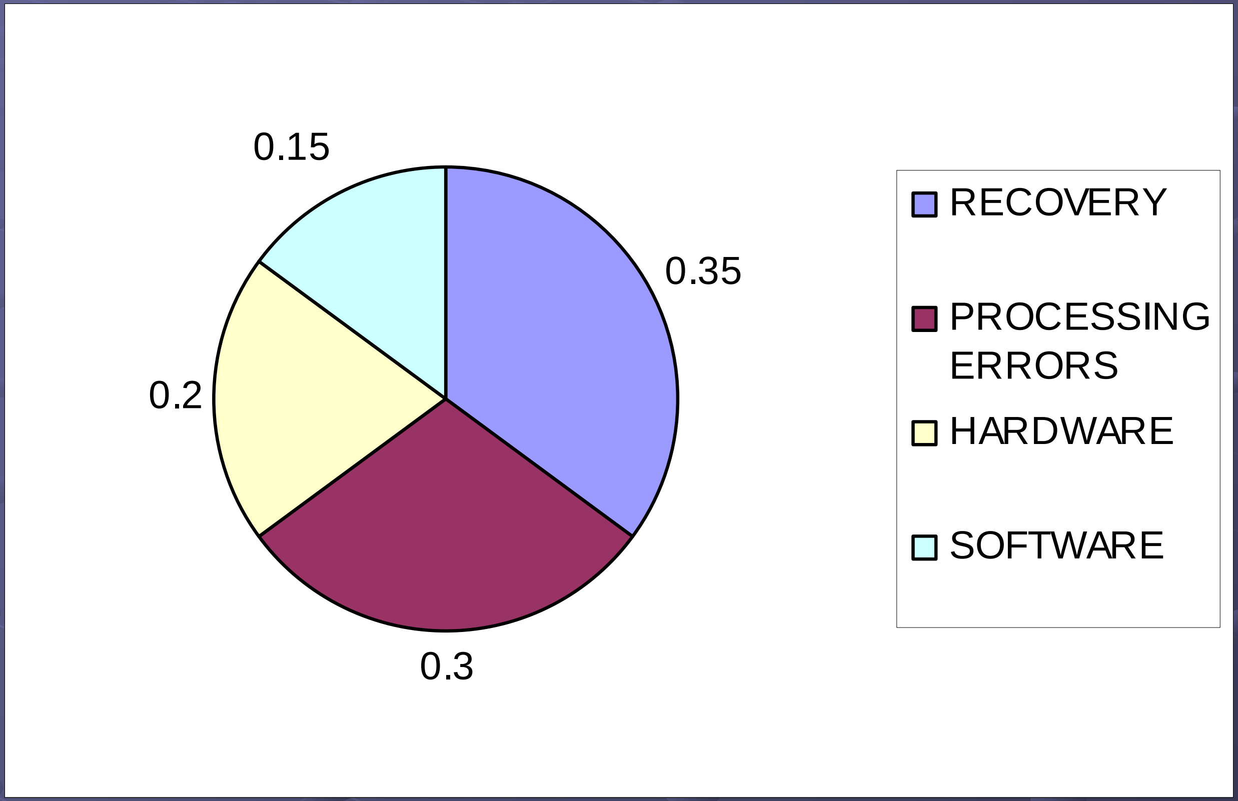
"The main line software code usually does its job. Breakdowns typically occur when the software exception code does not properly handle abnormal input or environmental conditions – or when an interface does not respond in the anticipated or desired manner."

C. K. Hansen, *The Status of Reliability Engineering Technology 2001*, Newsletter of the IEEE Reliability Society, January 2001

SOME SPECTACULARS

- THERAC-25 FATAL RADIATION OVERDOSES
  - DID NOT SUPPRESS OPERATOR INPUT WHILE MAGNETS WERE REPOSITIONED
- ARIANE 5 CRASHED AFTER LAUNCH
  - DISABLED LANGUAGE PROVIDED EXC. HANDL.
  - PERMITTED SHUT-DOWN OF BOTH NAV SYST.
- MARS POLAR LANDER HARD LANDED
  - FAILURE TO DE-BOUNCE CONTACTS

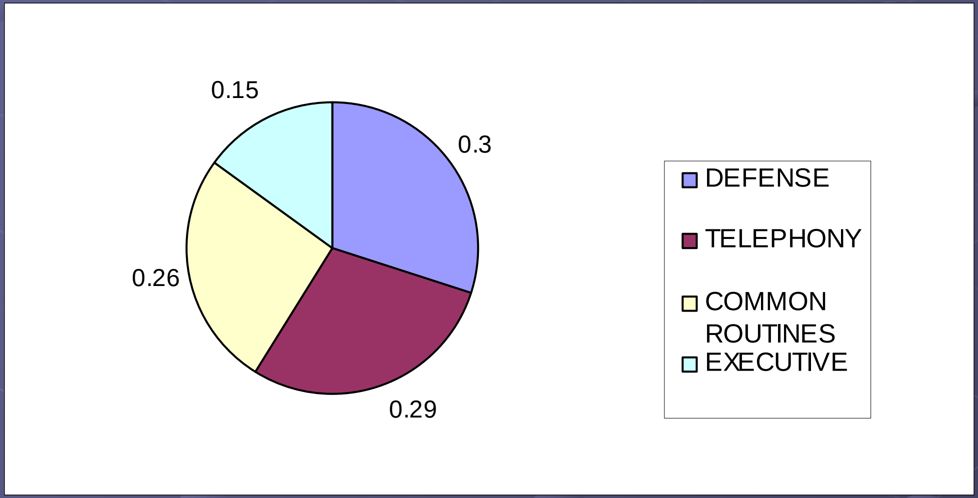
IMPORTANCE OF EXCEPTION HANDLING - 1



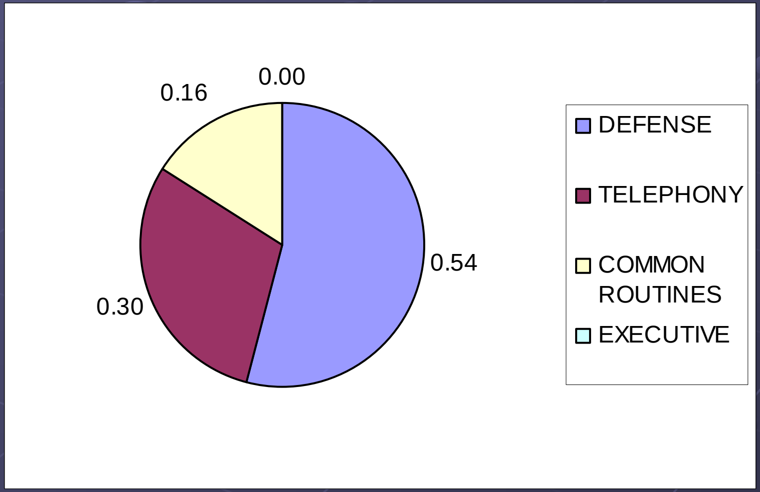
Toy, W. N., “Fault-Tolerant Design of AT&T Telephone Switching Systems” in *Reliable Computer Systems: design and evaluation,* Siewiorek and Swarz, eds., Digital Press, Burlington MA, 1992

IMPORTANCE OF EXCEPTION HANDLING - 2

ALL FAILURES

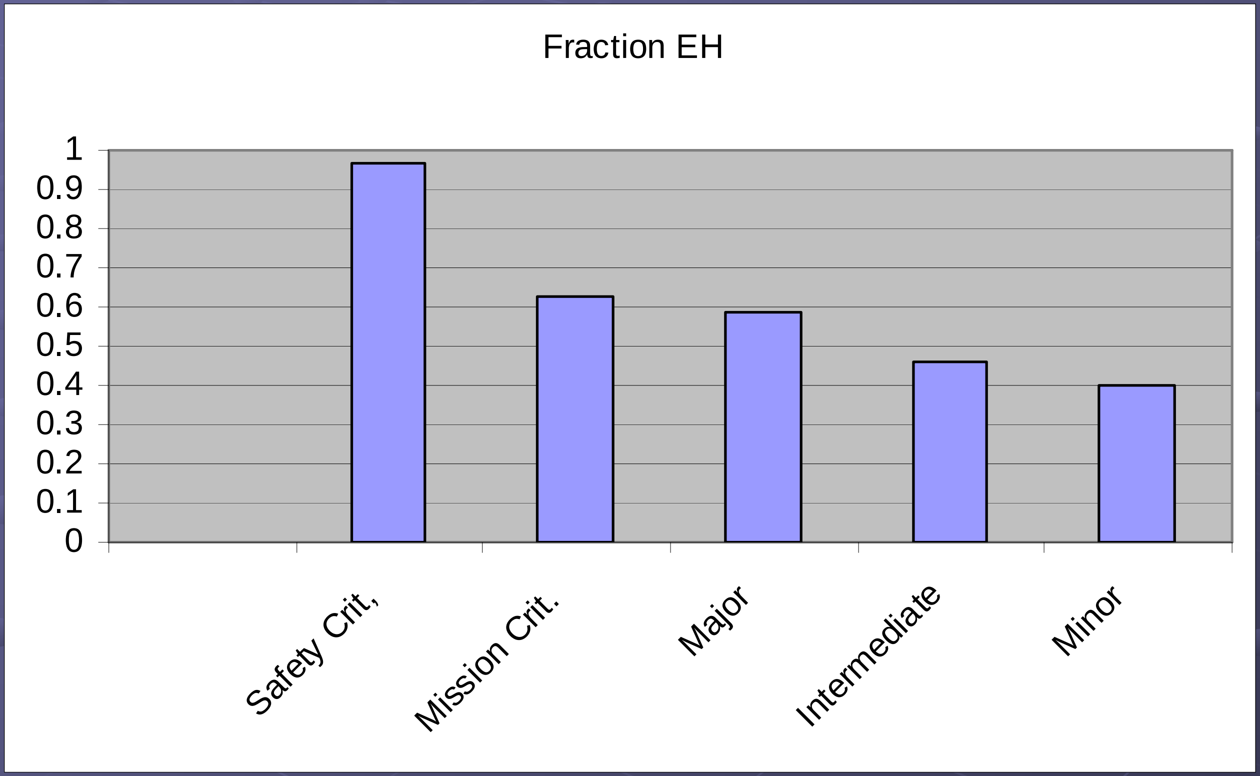


GLOBAL FAILURES



Kanoun, K. and T. Sabourin, “Software Dependability of a Telephone Switching System”, *Digest of Papers, FTCS-17,* Pittsburgh PA, July 1987, pp. 236 – 241

EXCEPTION HANDLING AND CRITICALITY



Hecht, H. and P. Crane, “Rare Conditions and their Effect on Software Failures”, *Proc. of the 1994 Annual Reliability and Maintainability Symposium”,* January 1994, pp. 334 – 337.

RELEVANT QUOTES

“The main line software code usually does its job. Breakdowns typically occur when the software exception code does not properly handle abnormal input or environmental conditions – or when an interface does not respond in the anticipated or desired manner.”

C. K. Hansen, *The Status of Reliability Engineering Technology 2001*, Newsletter of the IEEE Reliability Society, January 2001

“Therefore the identification and handling of the exceptional situations that might occur is often just as (un)reliable as human intuition.”

Flaviu Cristian “Exception Handling and Tolerance of Software Faults” in *Software Fault Tolerance,* Michael R. Lyu, ed., Wiley, New York, 1995

WHY THESE FAILURES?

- THE PROGRAMS WERE NOT TESTED UNDER THE CONDITIONS THAT CAUSED THE FAILURES
- THERE WERE NO REQUIREMENTS FOR TESTING UNDER THESE CONDITIONS
- GENERATING REQUIREMENTS FOR EXCEPTION HANDLING IS ***DIFFICULT***

WHY THE DIFFICULTY?

- EXCEPTION CONDITIONS ARISE FROM SEVERAL LEVELS
- EXCEPTION CONDITIONS ARE MORE DIFFICULT TO UNDERSTAND THAN MAIN LINE REQUIREMENTS
- EXCEPTIONS OCCUR INFREQUENTLY BUT REQUIRE DISPROPORTIONATE EFFORT

SOURCES OF EXCEPTIONS

OPERATIONAL REQUIREMENTS

- LOSS OF POWER, COMMUNICATION, THERMAL CONTROL

IMPLEMENTATION DETAIL

- CALIBRATION ANOMALIES, ACTUATOR STATES, OPERATOR INPUT

COMPUTING ENVIRONMENT

- HARDWARE FAILURES, MEMORY ERRORS, EXECUTIVE, MIDDLEWARE

MONITORING AND SELF-TEST

- OVER-TEMPERATURE SENSORS, SYSTEM PERFORMANCE TEST

APPLICATION SOFTWARE

- ASSERTIONS, VIOLATION OF TIMING CONSTRAINTS, MODE CHANGES

WHO IS RESPONSIBLE?

OPERATIONAL REQUIREMENTS

SYSTEM ENGINEERING

IMPLEMENTATION DETAILS

EQUIPMEMT SPECIALIST

COMPUTING ENVIRONMENT

VEHICLE HEALTH MGM'T

MONITORING AND SELF-TEST

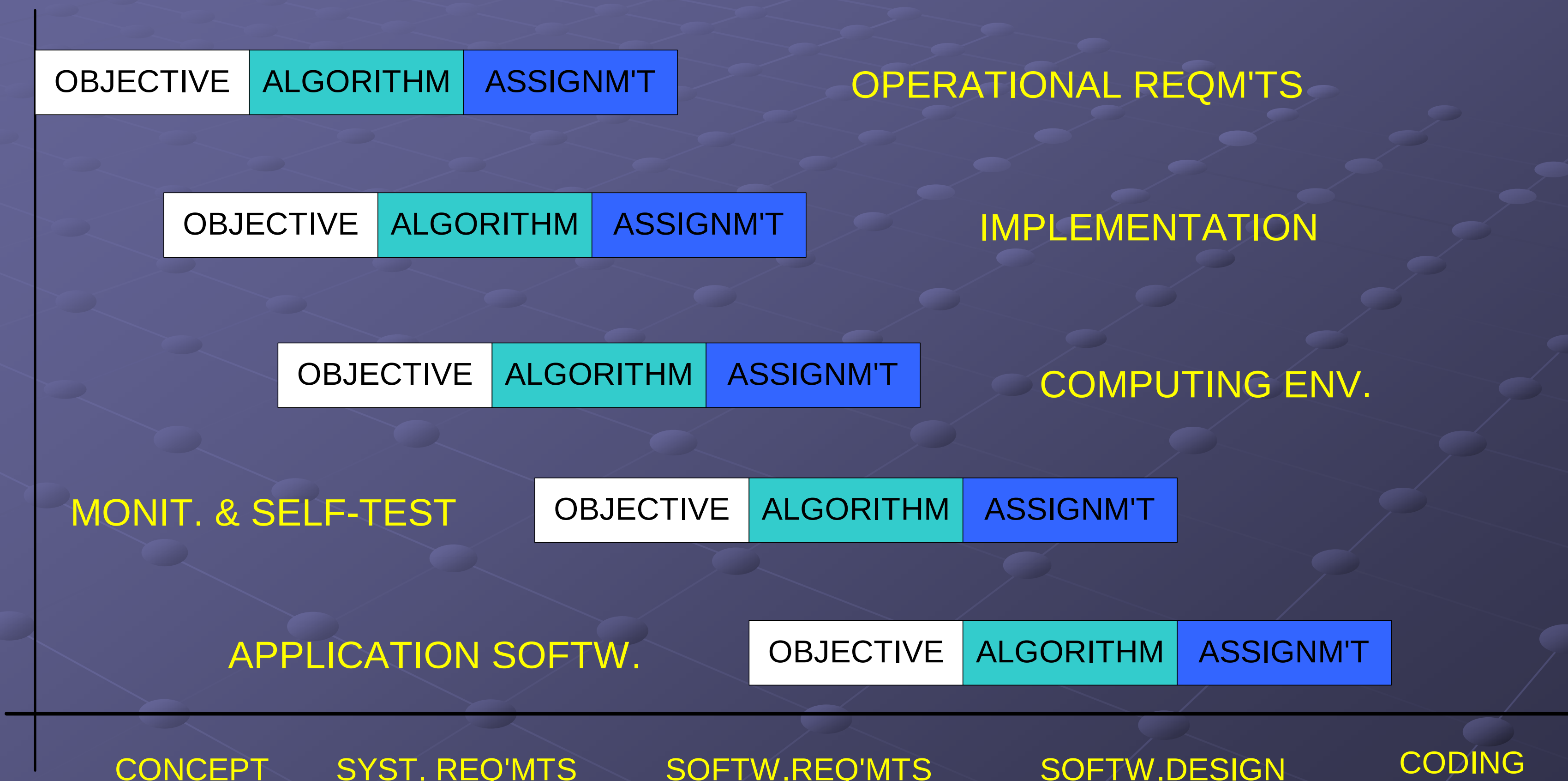
APPLICATION SOFTWARE

SOFTWARE ENGINEERING

REQUIREMENT GENERATION

- OBJECTIVE
  - EXCEPTION CONDITION AND ACTION
- ALGORITHM
  - QUANTITATIVE CONDITION DESCRIPTION
  - TIMING AND RESPONSIBILITY FOR ACTION
- ASSIGNMENT
  - SPECIFY SOFTWARE IMPLEMENTATION OF ALGORITHM

DOES IT ADD UP?



BUILDING BLOCKS

- EXISTING PRACTICES
- EXPERIENCE
- TOOLS

- INTEREST GROUP
- WORKING GROUP
- RECOMMENDED PRACTICE

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Transdyne Corporation
CMMI Implementations in Small & Medium Organizations
SEI ID No. 0100145-01

CMMI℠ Instructional Challenges for Systems Engineers in Small and Medium Organizations

Dr. Mary Anne Herndon

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mah@transdynecorp.com
http://transdynecorp.com

SEI Partner

Agenda: CMMI^{SM} Instructional Challenges for Systems Engineers in Small Settings

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Small & Medium Organizations

- SE Process Improvement Background
- Overview of Process Areas and Representations
- SE Services Paradigm: SE Vee for Small to Medium Organizations
- SE Services Background Descriptions and Examples of Project Documents by Process Category
  - Process Management
  - Project Management
  - Engineering
  - Support
- Comparison of CMMI Implementation Success Factors and Organization Size

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Process Improvement Background: Circa 1910

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Pre CMMI History and Influences

- The history of process improvement has origins back to the turn of the century during the American industrial age.
  The establishment of assembly lines by Henry Ford caused a demand for skilled workers.
- The early assembly lines were plagued with quality problems which were not discovered usually until the final part was inserted into the Model T Ford.
- The scrap pile was substantial, which increased the cost to the consumer.
- An additional quality problem was detected in the manufacturing of gun casings in WWI that exploded upon firing and caused casualties.
- Faced with these and other manufacturing quality control challenges, early pioneers of process improvement, such as Joseph Juran, Walter Shewhart, W. Edwards Deming, Phil Crosby and later workers, such as Watts Humphrey of the Software Engineering Institute decided to focus on the process and not just inspecting the products.

CMMI

CMMI v1.2: Process Improvement Model Heritage

Key Process Model	Timeline
S/W CMM	1995
S/W CMM v2.0	Never released
System Engineering (SE) CMM	**1995**
Integrated Product Development (IPD) CMM	1997
Electronic Industries Association (EIA) 731 (Systems Engineering)	**1998**
CMMI v1.1	**March, 2002**
CMMI v1.2	**August, 2006**

- The heritage of CMMI v1.2 comes from numerous ISO, IEEE, EIA and SEI models.

- The CMMI is an integrated model from EIA 731, S/W Capability Maturity Model (CMM) v2.0 and Integrated Product Development Capability Maturity Model.

Note of Special Importance: The Usefulness of Models

"All models are wrong, but some are useful."
George Box
(Quality and Statistics Engineer)

- **A CMMI model is not a process.**
- **A CMMI model describes the characteristics of effective processes.**

CMMI v1.2 Benefits for Small – Medium SE Services and Development Organizations

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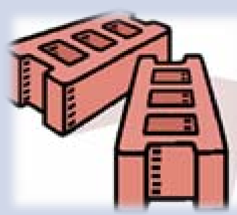
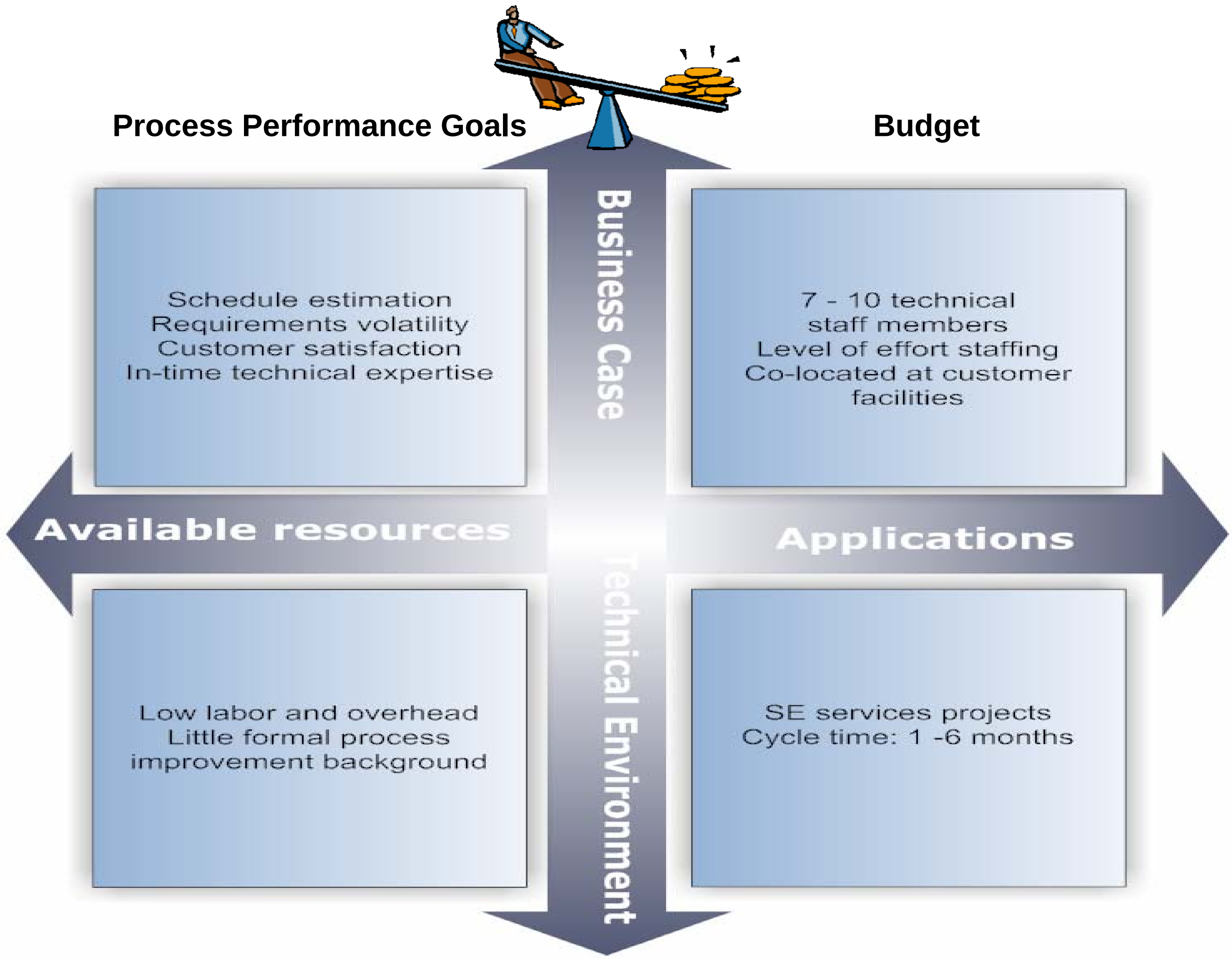
Small – Medium Organizations	Benefits
 	The CMMI model is a structured set of good management practices collected from practitioners across private industry and government organizations.
   	Implementation of CMMI model assists organizations by providing processes to: 1. Understand the current organizational maturity and process capabilities 2. Improve current capabilities to achieve business performance goals, such as performance and quality 3. Plan and implement improvements

Process Improvement Paradigm: Balancing Resources and SE Services Business Case



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SE Services Perspective: Overview of CMMI v1.2 Process Areas (PAs)

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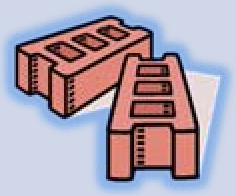
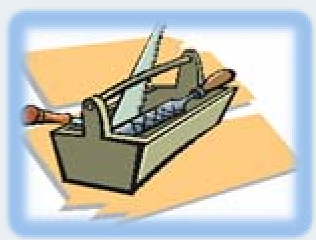
Process Area	Benefits
1. Function  	Process Area is a cluster of related practices in an area that, when implemented collectively, satisfy a set of goals considered important for making improvement in that area. The PAs are used as building blocks to construct a foundation for improving process performance.
2. Purpose 	These practices provide organizations a set of proven management tools that are non-prescriptive (never a set of implementation practices).
3. Implementation  	Each SE services organization should determine how to implement these practices within their organizations always from a pragmatic, **"what makes sense"** perspective.

CMMI

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Avoiding Confusion on the Two Model Representations

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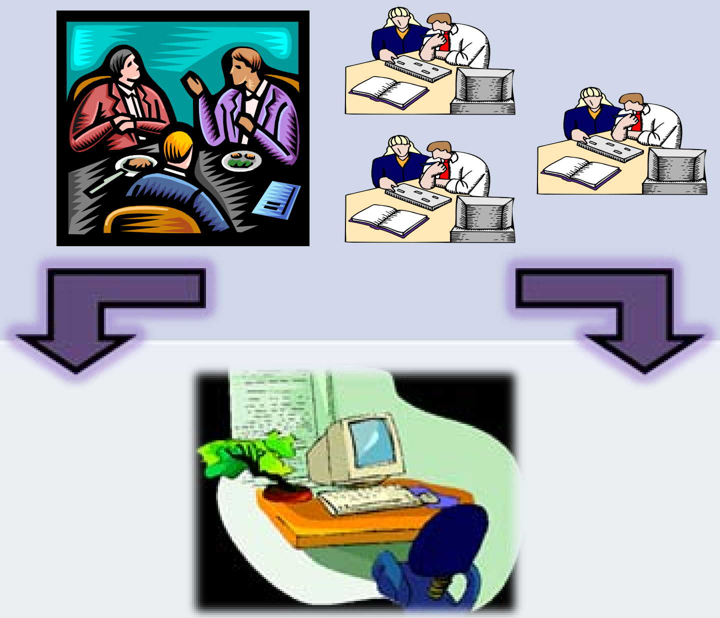
The **same** 22 Process Areas are arranged in 2 different ways.

Continuous and Staged Representations



The continuous and staged representations provide two views into the **SAME** data base of information, the 22 CMMI v1.2 Process Areas.

Comparison of Continuous and Staged Representations

	Continuous		Staged		Both together
implementation flexibility	✓				✓
Maturity Levels			✓		✓
Capability Levels	✓				✓
satisfy the business goals	✓		✓		✓
provides layers in process improvement	✓		✓		✓
pre-defined sets of process areas			✓		✓
Use SCAMPI appraisal methods	✓		✓		✓
Process Areas in Process Categories	✓				✓
Process Areas in Maturity Levels			✓		✓
Obtain a benchmark			✓		✓

SE Services Paradigm: Participation in the SE Vee Activities for Small to Medium Organizations

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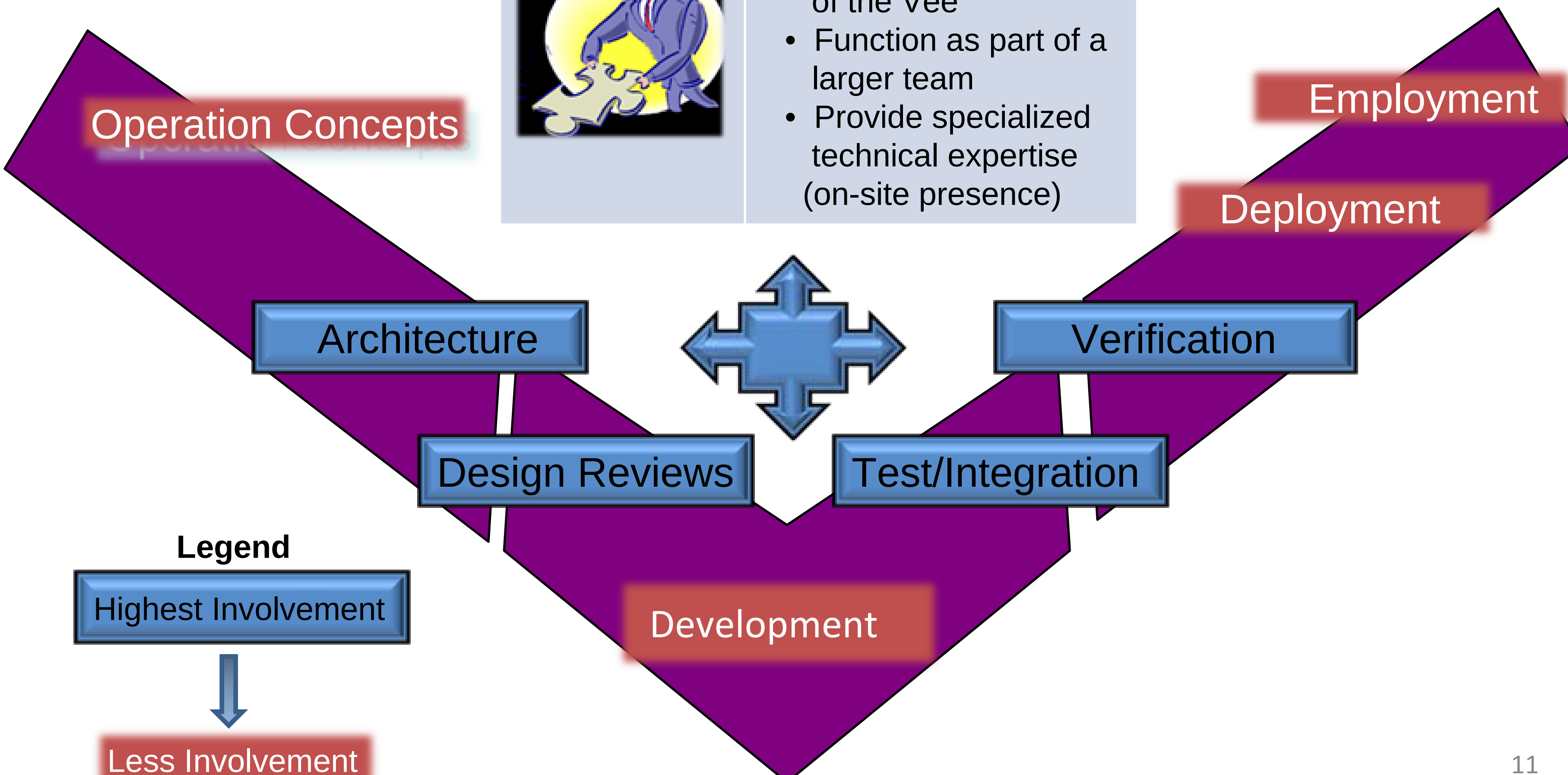
Types of Roles	Small – Medium SE Services Organizations
	• Support tasks in parts of the Vee • Function as part of a larger team • Provide specialized technical expertise (on-site presence)



Context for SE Services Background Descriptions and Project Examples

	**The samples of SE services background descriptions and examples of project documents are more applicable to small and medium organizations than larger corporations.**
	The small to medium SE services organizations often function as team members that supply expertise in specialized technical domains or provide on-site technical support, such as in analysis, verification and validation tasks.
	The SE services background descriptions and examples of project documents are for the Process Areas in Maturity Level 3, excluding IPPD.

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SE Services Background Descriptions and Examples
Process Category: Process Management

Process Category	Process Areas
Process Management	**Organizational Process Focus** **Organizational Process Definition + IPPD** **Organizational Training** Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management + IPPD Risk Management Quantitative Project Management
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution

Process Category: Process Management

SE Services Background	Process Area	Examples of Project Documents
SE services practitioners rarely participate in setting up formal process improvement organizations, documenting processes and defining process performance measurements.	Organizational Process Focus (OPF)	Documentation of participation in formal appraisals (with the exception of ISO audits) or EIA 731 are uncommon in these environments. Organizational business plans may provide documentation of process performance goals, such as customer satisfaction or improvements in schedule estimation.
SE services practitioners often use work aids, such as templates, as a guide to scheduling tasks in their projects.	Organizational Process Definition (OPD)	Templates often are used to document processes for small – medium SE services organizations. These templates are often used to plan and collect performance measurements, such as delivery schedules, hours expended, action items and review attendance.
SE service practitioners value organizations that provide training to keep technical skills current.	Organizational Training (OT)	EMAILs or announcements of existing “brown bag” sessions or presentations by invited technology advocates.

SE Services Background Descriptions and Examples
Process Category: Project Management

Process Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition + IPPD Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	**Project Planning** **Project Monitoring and Control** **Supplier Agreement Management** **Integrated Project Management** + IPPD **Risk Management** Quantitative Project Management
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution

Process Category: Project Management

SE Services Background	Process Area	Examples of Project Documents
SE services managers usually are familiar with the activities in these PAs, with the exception of formal risk management. **SE services managers and practitioners need to accurately estimate schedules, including adequate preparation time for technical reports and review packages.**	Project Planning (PP)	Project planning information if often found in the management sections of proposals and usually contains: 1. Estimation of LOE staffing and project schedules. 2. Risk identification either to the cost or schedule baselines as opposed to technical risks. 3. Planning for specialized technical knowledge or staff willing to relocate 4. Planning for management of technical reports
Action item tracking is a key project management task as the majority of the action items often directly impact the customer	Project Monitoring & Control (PMC)	Progress reports and technical review packages often document tracking and resolution of customer sensitive technical issues.

Process Category: Project Management (continued)

SE Services Background	Process Area	Examples of Project Documents
The engineers interact with the technical points of contact of suppliers, frequently as team members. Managers are tasked with supplier cost and schedule management and obtain technical performance status from engineers.	Supplier Agreement Management (SAM)	Progress reports showing status of technical performance and acceptance reports documenting delivery hardware or software
Identified risks to SE services organization typically are assessed to the cost and schedule baselines. Technical risk assessment is appropriate if organization is providing System Engineering and Technical Analysis oversight for the customer.	Risk Management (RSKM)	Progress report or technical review packages showing risk evaluations, using appropriate classification categories.
SE organizations usually do not have extensive documented processes unless provided by team member or customer. Standard work environment may be determined by the contract.	Integrated Project Management (IPM)	Technical review packages or progress reports using a customer or team member provided templates.

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SE Services Background Descriptions and Examples
Process Category: Engineering

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Process Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition + IPPD Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management + IPPD Risk Management Quantitative Project Management
Engineering	**Requirements Management** **Requirements Development** **Technical Solution** **Product Integration** **Verification** **Validation**
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution

Process Category: Engineering

SE Services Background	Process Area	Examples of Project Documents
SE services managers and engineers usually are directly involved with customers in developing technical performance requirements. As a team member, the engineers are involved in defining operational concepts and performing analysis to balance technical performance, cost and schedule.	Requirements Development (RD)	Visit reports and minutes of technical meetings with customer technical interchanges
SE services managers and engineers often serve as members of change control boards and provide significant contributions to tracking inconsistencies and defects to manage requirements changes.	Requirements Management (REQM)	Technical progress reports containing information describing inconsistencies or detected defects in requirements. Minutes of configuration control boards document recommendations and formal changes.

Process Category: Engineering (continued)

SE Services Background	Process Area	Examples of Project Documents
SE services projects are usually focused on providing technical analysis of system functions in their specialized domains. While providing technical support for customers, their analysis is limited to these specific functions.	Technical Solution (TS)	Visit reports and minutes of technical meetings with customer technical interchanges. Progress reports often provide excellent examples of engineers participation in providing technical performance analysis.
SE services organizations are often tasked with specific product integration activities, such as conducting readiness reviews or providing on-site support at the integration facility.	Product Integration (PI)	Technical progress reports containing information describing integration status as well as generated action items.

Process Category: Engineering (continued)

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SE Services Background	Process Area	Examples of Project Documents
SE services engineers perform verification of requirements and designs in their specialized domains. While providing verification resources for customers, their testing and analysis is limited to the specific system functions.	Verification (VER)	Visit reports and minutes of technical meetings with customer technical interchanges. Progress reports often provide excellent examples of participation in the different verification tasks (requirements, design and testing).
SE services organizations are often tasked to provide on-site engineers to develop validation plans or to conduct or witness these tests. with specific product	Validation (VAL)	Examples of technical reports documenting the results of validation tests. Technical progress reports containing information describing integration status as well as generated action items.

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SE Services Background Descriptions and Examples
Process Category: Support

Process Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition + IPPD Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management + IPPD Risk Management Quantitative Project Management
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	**Configuration Management** **Process and Product Quality Assurance** **Measurement and Analysis** Causal Analysis and Resolution **Decision Analysis and Resolution**

Process Category: Support

SE Services Background	Process Area	Examples of Project Documents
SE services organization typically interface to CM systems in larger projects or may be tasked to function as the CM manager. The engineers often are members of configuration control boards with authority in specialized technical domains.	Configuration Management (CM)	Copies of configuration status reports showing technical points of contact for controlled documents. Copies of configuration control board meetings and action items.
SE services organizations typically do not perform “formal” quality assurance activities for their projects. There may be participation in the QA activities performed on larger projects Participation by engineers in informal peer reviews is a more frequent implementation of objective evaluation.	Process and Product Quality Assurance (PPQA)	Reports containing documentation of non-compliance or technical reports documenting problems detected during “peer reviews”.

Process Category: Support (continued)

SE Services Background	Process Area	Examples of Project Documents
SE services project managers typically report cost and schedule performance measurements as part of progress reports and status reviews. Technical performance measurements are reported while defining and refining operational concepts and performing analysis to balance technical performance, cost and schedule or performance testing.	Measurement and Analysis (MA)	Technical progress reports containing project status information or analysis of planned functional performance or actual performance measurements collected during testing.
Selection of alternative hardware or architectures is documented in technical reports, usually as "trade studies".	Decision Analysis and Resolution (DAR)	Technical reports documenting selection criteria and evaluation of alternatives.

Summary: Comparison of CMMI Implementation Success Factors and Organization Size

CMMI Implementation Success Factors	small settings		large organizations
flatter organization	✓		
efficient communication skills	✓		
flexible processes	✓		
depth of understanding of the business goals	✓		
staff involvement	✓		
staff receptiveness to new ideas	✓		
awareness of existing processes	✓		
simpler process performance models	✓		
process variance simpler to control	✓		
less diversity in products and services	✓		

Small & medium organizations are not “miniatures” of large corporations!

Smaller organizations provide a conducive environment to implement CMMI practices due to:

1. simplicity of organizational structure
2. efficient communications
3. staff receptiveness of new ideas
4. depth of awareness of the processes
5. easier to minimize variance in performing key processes

The End

	**You have just seen background descriptions and examples of project documents for SE services organizations from the "30,000 feet" level.**
	Questions or Comments ?

Disclaimer

The Opinions Expressed by the Speaker

Are His Own

and

Do Not Necessarily Reflect Anyone Else's

..although

They Might!

How to Paint a Room

The Role of Specs & Standards in the Systems Engineering… ..Business!

Robert B. "Scott" Kuhnen

ASC/AFRL Eng Stds Office

Wright-Patterson AFB OH

24 October 2007

Shall We Get Started?

Not so fast!!!

- “Proper interior paint preparation of your walls and ceilings before painting will often encompass more work than the actual painting. Up to 75% of the work can be getting a surface ready for painting.”

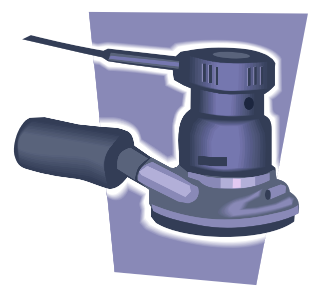
- Karl Crowder
- http://www.house-painting-info.com/index.html

Tools for Prepping Walls

- Safety glasses or goggles
- Respirator or face mask
- Ear protectors
- Rubber gloves
- Pry bar
- Paint scraper
- Wallpaper steamer (rent if needed)
- Can opener or widening tool
- Fan
- Hand sanding block
- Orbital sander
- Screwdriver
- Putty knife
- Sponge
- Cap or scarf
- Old clothes







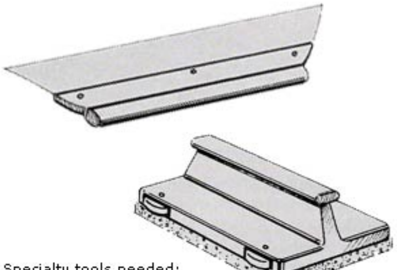
Materials for Prepping Walls

- Spackle (compound)
- Fine-grit sandpaper
  - (100 - 120-grit silicon carbide)
- Detergent and ammonia or tri-sodium phosphate (TSP)

- Self-adhesive drywall tape
- Primer or adhesive pad
- Sizing (for wallpapering)

Tools for Painting

- Drop cloths
- Ladders
- Buckets
- Paint edger
- Brushes, 4", 3", and 11/2"
- Angled sash brushes, 1 1/2" and 2"
- Roller pan with screen
- Roller covers with appropriate naps
- Roller handle
- Roller extender
- Paint guide

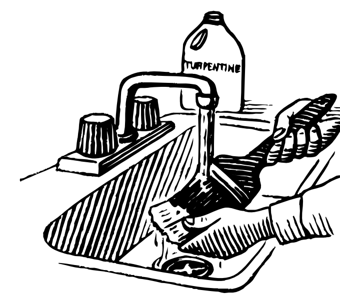


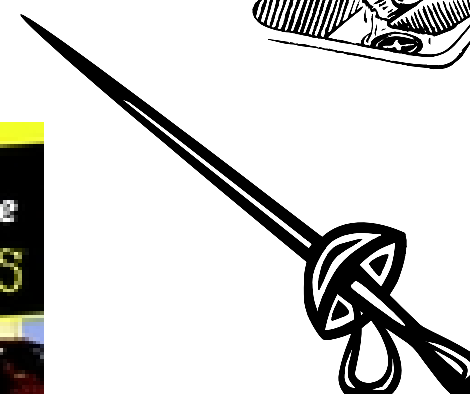
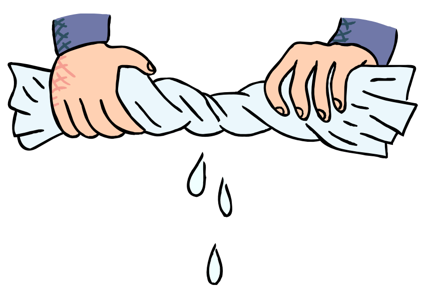
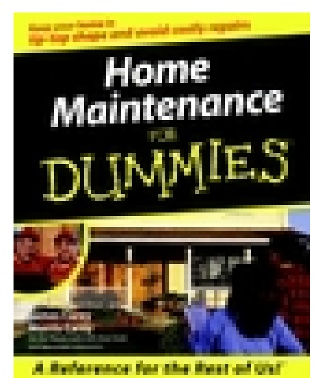
Specialty tools needed: a paint guide and a paint edger. Both can be used for "cutting in."

Materials for Painting

- Masking tape, 2" wide
- Newspaper
- Adhesive pad or primer
- Paint thinner (with oil-based paints)
- Aluminum foil
- Rags





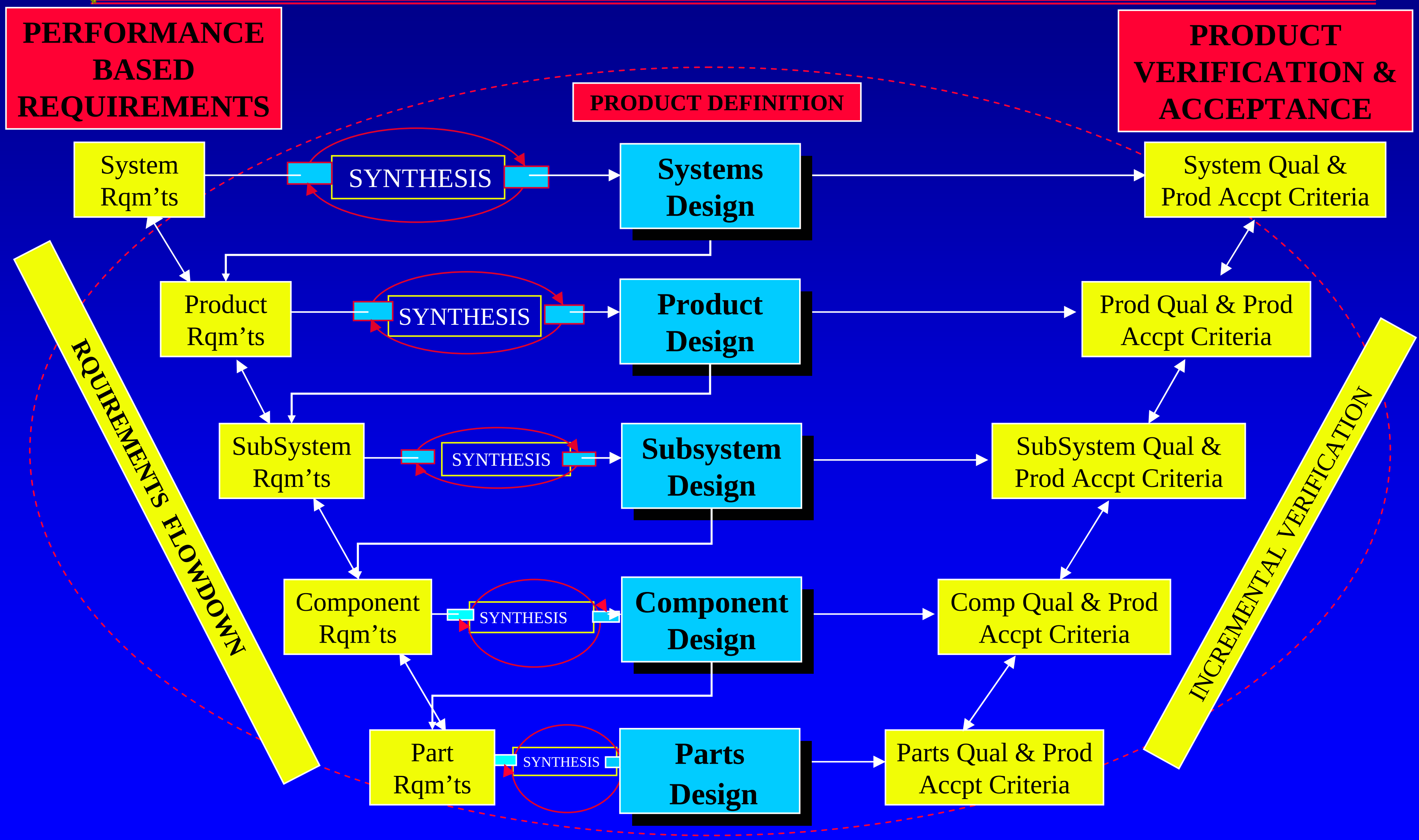




What the experts say…

- Most people think they know how to paint, and usually the results are pretty good. But for painting contractor John Dee, "pretty good" isn't good enough. After nearly three decades of rolling, brushing, and spraying paint he knows the subtle tricks for applying smooth, even coats to walls, ceilings, and woodwork, and for creating crisp boundaries between colors.

According to Dee, there's no magic to getting professional-looking results. Practice helps, and thorough surface preparation is essential. But the key, he says, is to paint in an orderly, systematic way. So whether he's painting a multi-paneled door or a flat expanse of wall, he proceeds almost scientifically from one step to the next, with no shortcuts. "Your approach to the task, the order in which you do things, can speed the work or slow you down," Dee says. "Here's the approach that works best for me."

ENGINEERING DESIGN PROCESS



There are lots of experts…

- “At Mario’s Painting, we believe that the secret to achieving flawless-looking, beautiful surfaces both inside and outside your home lies in the pre-painting preparation. Where some companies may try to cut costs by cutting back on quality preparation time, we put in a full day’s work before the first coat of primer even goes on your walls.”

- Preparing the surface is the most important part of any painting project. If the paint doesn't have a smooth, clean surface to adhere to, the result will be a poor-quality job that doesn't last very long. "You should spend at least as much time on surface prep as you will be painting," advises Horst.

- If it's worth doing, it's worth doing right the first time. And proper preparation is the key. Few of us really realize this, or even like to admit it, since it leads to more work. It is a step that is all too often left out, and the final job reflects its omission. It is too easy just to start painting and not go through the necessary prep steps. Indeed, for a while the paint job may even look pretty good. But sooner or later the poor quality will show up.

Talking about painting or…SE?

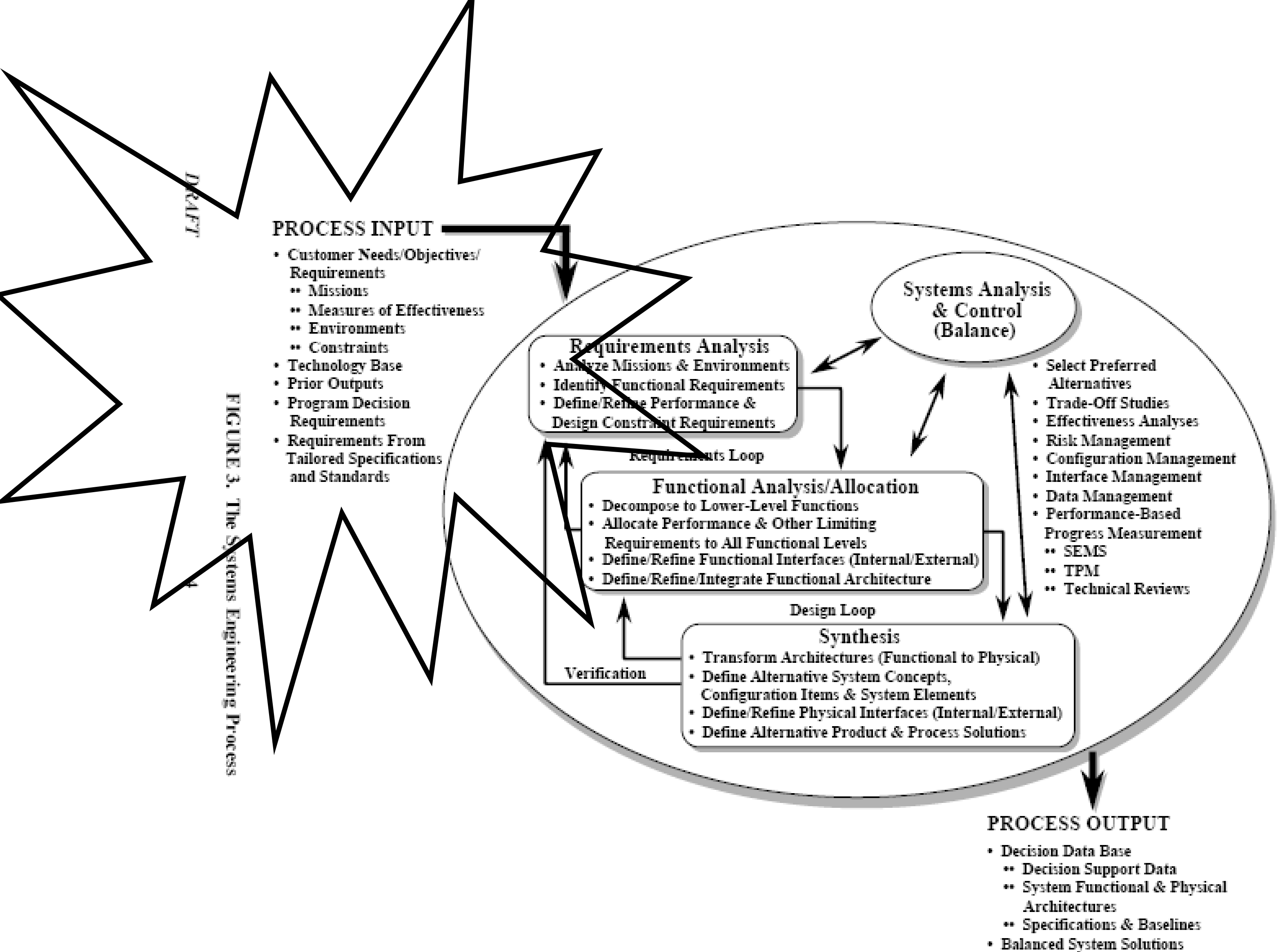
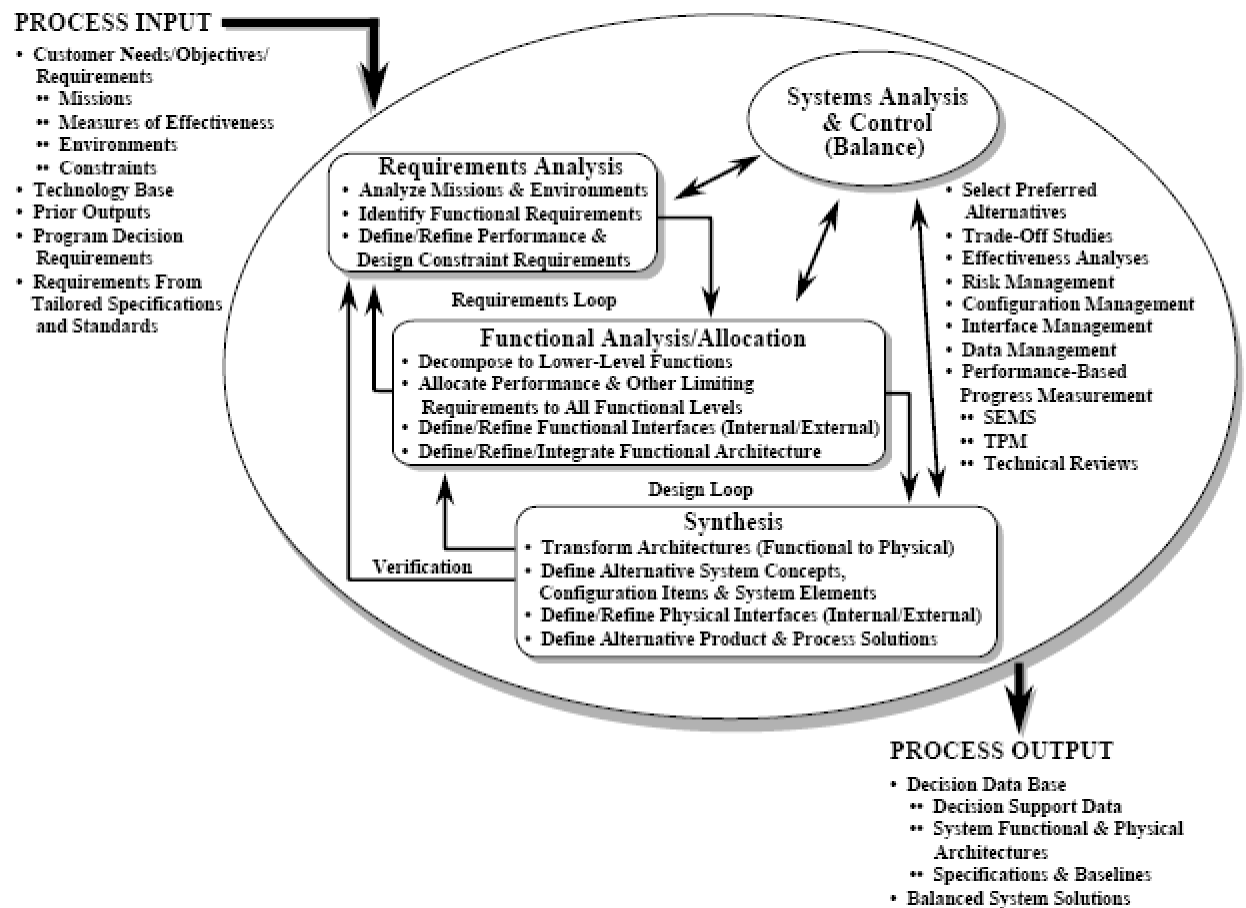


FIGURE 3. The Systems Engineering Process

- Defense Specifications
- Defense Standards
- Qualified Products Lists
- Non-Gov’t Standards
- Int’l Standards
- etc.



DRAFT

FIGURE 3. The Systems Engineering Process

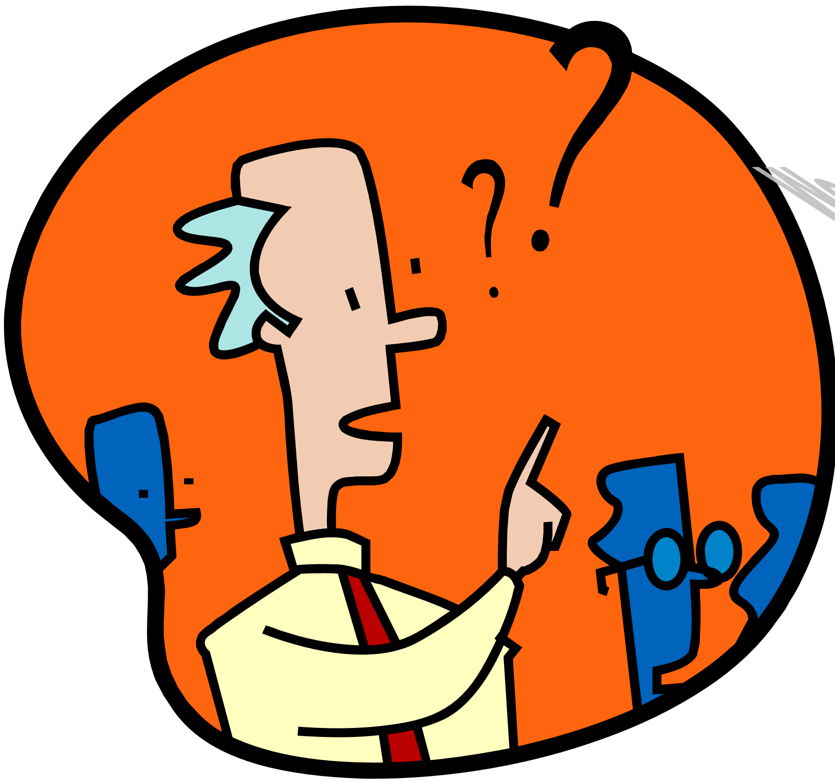
4

MIL-STD-499B

DRAFT

Discussion
Non-Attribution

We want your Feedback!



What are we missing?

Is SE Important?

What do you think?

Are there barriers to SE?

Is this catching on?

Are we on the right track?

Top Five Systems Engineering Issues

- Lack of awareness of the importance, value, timing, accountability, and organizational structure of SE on programs
- Adequate, qualified resources are generally not available within government and industry for allocation on major programs
- Insufficient SE tools and environments to effectively execute SE on programs
- Poor initial program formulation
- Requirements definition, development, and management is not applied consistently and effectively

NDIA Study in January 2003

DoD Systems Engineering Shortfalls*

- Root cause of failures on programs include:
  - Inadequate understanding of requirements
  - Lack of systems engineering discipline, authority, and resources
  - Lack of technical planning and oversight
  - Stovepipe developments with late integration
  - Lack of subject matter expertise
  - Availability of systems integration facilities
  - Low visibility of software risk
  - Technology maturity overestimated

Major contributors to poor program performance

* DoD-directed Studies/Reviews

Are We on the Right Track?

- Study Findings
  - Inadequate understanding of requirements
  - Lack of SE discipline, authority, and resources
  - Lack of technical planning and oversight
  - Stovepipe developments with late integration
  - Lack of subject matter expertise at integration level

- Programs/SEPs
  - Incomplete discussion of program requirements
  - Minimal discussion of technical authority and IPTs
  - Incomplete technical baseline approach
  - Incomplete discussion of technical reviews
  - Integration of SEP sections

Strong correlation between initial findings and SEP and Program Support findings

Could the problem be…?

A PennWell Publication

Military & Aerospace ELECTRONICS™

Vol. 5, No. 9 — The Engineering Newspaper for the Worldwide Mil/Aero Electronics Industry — August 1994

Perry scraps mil-specs

By Bruce Rayner

WASHINGTON, DC—In late June, Defense Secretary William Perry ordered a dramatic about face in the Defense Department's use of military specifications and standards, ordering that all DoD programs rely more heavily on commercial parts and adopt a performance-based specification process.

While Perry's announcement was widely anticipated and publicly applauded by the defense electronics industry, many company officials are concerned that the changes will increase uncertainty in the acquisition process and threaten some existing systems that are operating well, such as the Qualified Manufacturing Line (QML), a DoD-specific system for certifying a manufacturing process.

"Right now it is a wait-and-see game," says Brad Paulsen, director of marketing for military and aerospace products at National Semiconductor (Santa Clara, CA). "There are a lot of issues that have not been clarified."

The directive, which will be phased in over the next six months, mandates that all DoD procurement contracts use commercial and industrial specs and standards where they exist; the use of mil-specs will require a waiver. Radiation-hardened components are exempt from the directive.

In another major change, program managers are now required to adopt performance-based specifications for new systems and major modifications. The performance specs describe how a system is to function but leaves the (Continued on page 32)

Secretary of Defense William Perry has introduced far reaching changes to the procurement process, including mandating the use of performance specs.

DoD has adopted....

*Systems engineering is an **interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and total life-cycle balanced set of system, people, and process solutions that satisfy customer needs.** Systems engineering is the **integrating mechanism** across the technical efforts related to the development, manufacturing, verification, deployment, operations, support, disposal of, and user training for systems and their life cycle processes. System engineering **develops technical information to support the program management decision-making process**. For example, systems engineers manage and control the definition and management of the system configuration and the translation of the system definition into work breakdown structures.*

Adopted from ANSI/EIA-632, "Processes for Engineering a System"

Systems Engineering Fundamentals from Past Programs

- SE was conducted by the design team
  - Systemic to the design process
  - Product of many designs by the same teammates over many programs and many years
- Common Characteristics: yesterday and today
  - Small, efficient systems engineering staff
    - Previous design engineers
      - Knack for requirements
      - Appreciated the larger challenge at the system level
  - Not always collocated and not always the same company

Source: Mr. John Griffin, former ASC/EN Director

Unintended consequences?

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(Continued on page 32)

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Unintended Consequences Abound

Reexamining Military Acquisition Reform

Are We There Yet?

Christopher H. Hanks, Elliot I. Axelband, Shuna Lindsay, Mohammed Rehan Malik, Brett D. Steele

Prepared for the United States Army

Approved for public release; distribution unlimited

RAND ARROYO CENTER

- "While the report is Army-centric, I believe the discussion would fit all of the Services. The report covers some 63 different acquisition reform initiatives, some of the observations related to Mil Specs…"
- "I think you want to look to where we need to be headed in the future."

Steve Lowell, DSPO

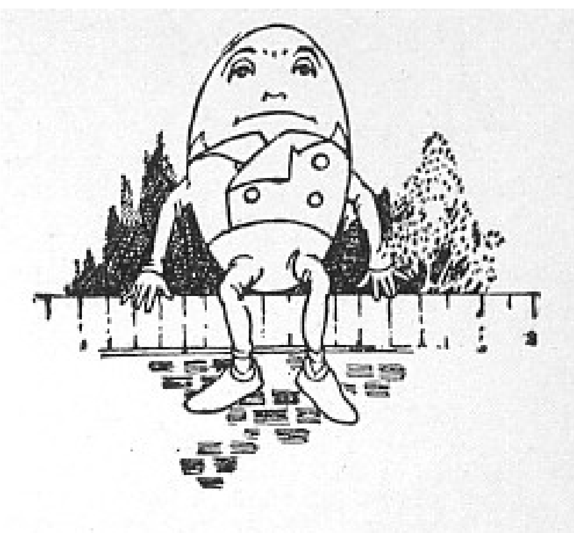
Examining Acq Reform…

- **The New Acquisition Environment Could Create Ongoing Problems**
  For many of the interviewees, some of the acquisition reforms implemented over the past decade may be creating an environment that will present ongoing problems. A deputy PM (civilian) said that the switch from mil specs to a performance-based approach (in which mil specs are not required as long as performance levels or specifications are met) has meant that the process has gone from "too tight to too fluffy." The use of "performance specs" in lieu of mil specs was already seen to be leading to problems with contractors, who are given a larger role in the process. On the one hand, contractors "now have far more freedom to get into trouble," as one individual put it in a group interview. On the other hand, some contractors do not know how to proceed with this new freedom, and could have trouble "implementing the discipline to handle their new responsibilities." Many contractors don't like the performance-based approach because of the uncertainty it entails. However, others are profiting from the new "vagueness" built into contracts. One deputy PEO (civilian) described a recent experience with a contractor: "The contract wanted to have everything quick, so it was vague, and now [we're] spending dearly for that vagueness. The contractor is . . . using the vagueness to do changes-so the vagueness is working to the contractor's benefit, not the government's."

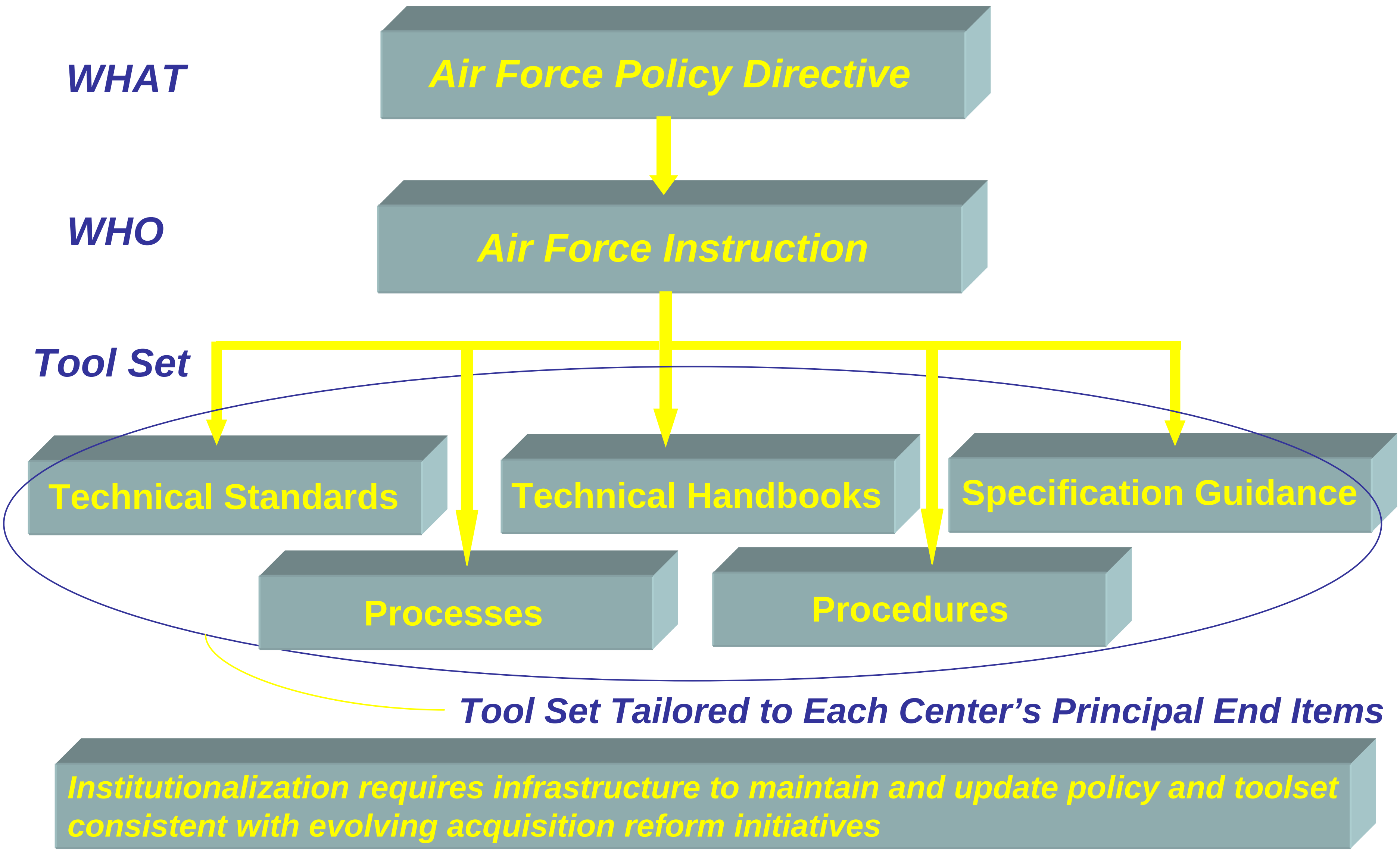
- One deputy PM (civilian) noted that the performance-based approach is not even increasing PM flexibility. Some interviewees mentioned that, without mil specs, many Technical Data Packages (TDPs) are not being updated and are now several years out of date. Some interviewees also questioned whether the reforms were really saving time or only shortening some processes while lengthening others. A PM staffer (civilian) noted, "Lots of regs are gone, but it's not clear things are taking less time as a result because other, different things are taking time to decide because we don't have the regs and specs to fall back on automatically. We've gone from "too much" to "too little."

Please recite with me…

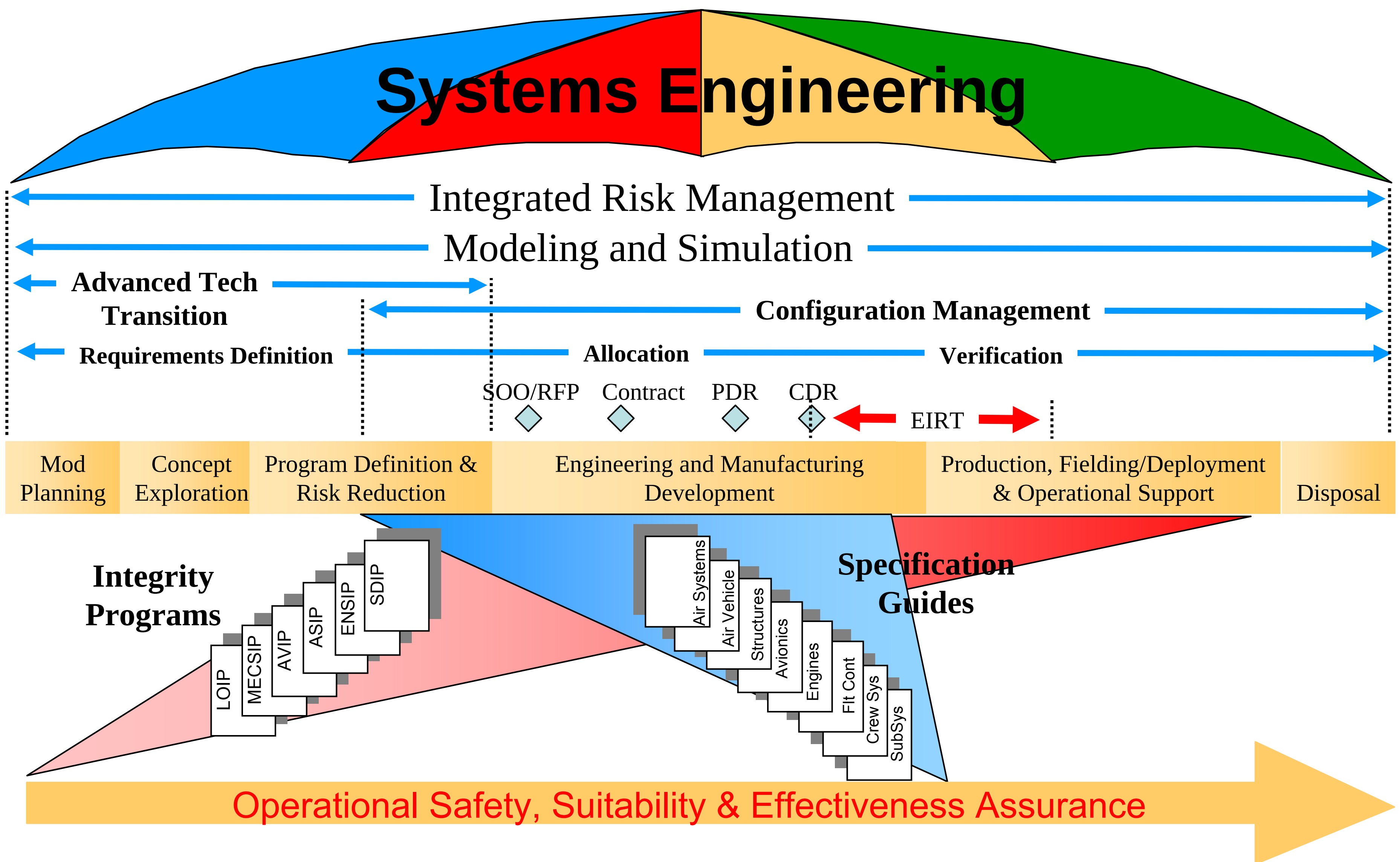
Humpty Dumpty sat on a wall,
Humpty Dumpty had a great fall.
All the King's Horses and
all the King's men
Couldn't put Humpty
together again!



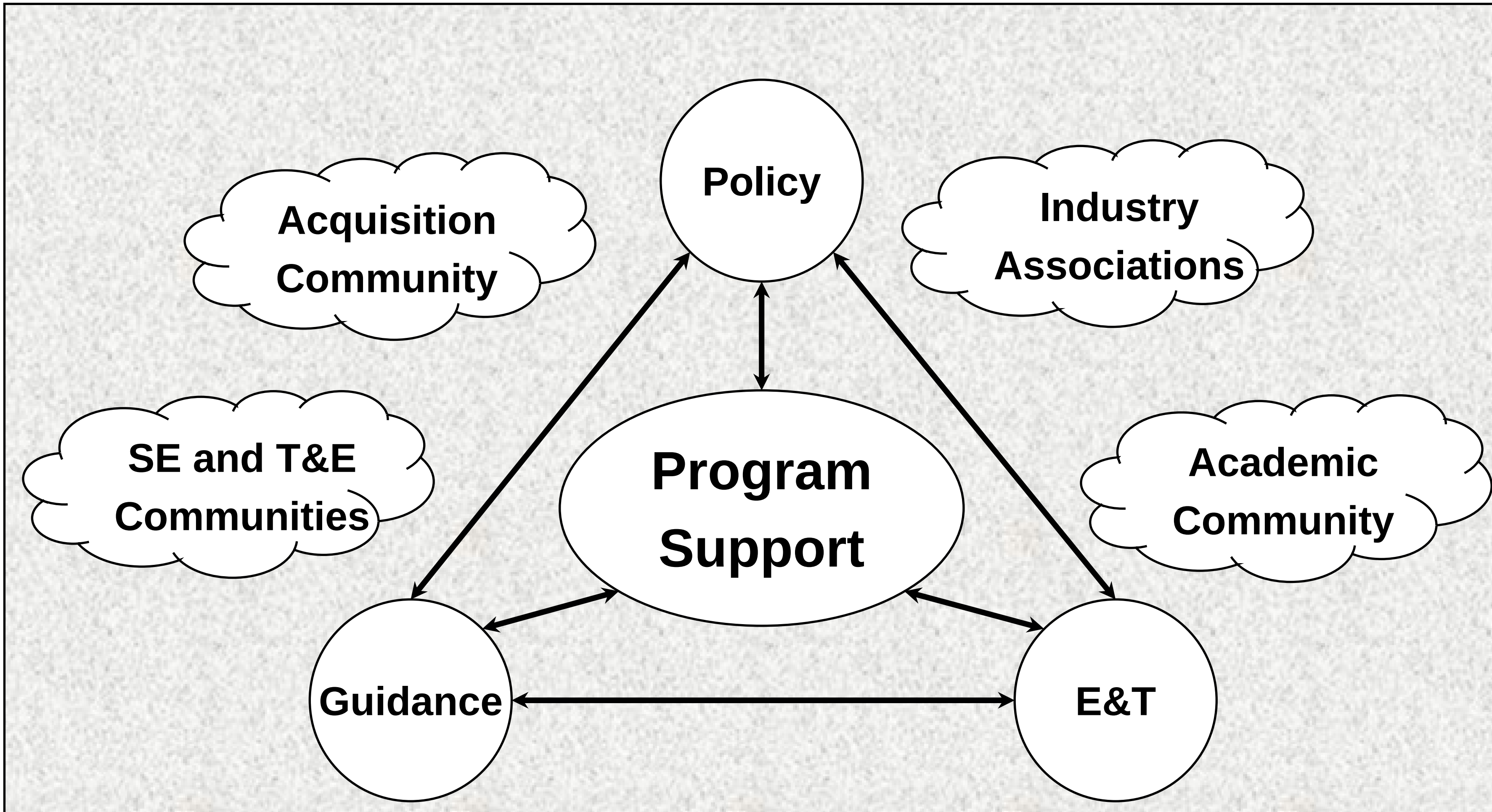
Institutionalizing OSS&E Through Regulatory Products



EN Technical Processes



Systems Engineering Revitalization Framework



Driving Technical Excellence into Programs!

Good Systems Engineering…

You'll know it when you see it?

or…

You'll know it only after you've verified that the product meets the specs & standards which define the product?

Fred Rall said…

- The best Statement of Work contains only three words:

“Meet the Spec!”

Concept Exploration

<u>Purpose</u>: evaluate alternative solutions to the initial concept; select preferred solution

<u>Characterized by</u>:

- Competitive, para... ...term studies
- ...
- ...nly
- Analysis of Alternatives (AoA)
- Work guided by the ICD*

Market research is key.

*MNS until CJCSI 3170.01 is revised

Concept and Technology Development Phase

Key Activities, continued

- Develop draft performance specification
- Identify potential environmen
  consequences
- Prepar
  (i
- E
- Prep
- Meet exit criteria for C&TD Phase
- Propose exit criteria for next phase

System level performance spec. Guide spec may be used to help draft system performance spec.

System Development & Demonstration Phase

Standards provide proven solutions to reduce risk.

Purpose:

- To develop a system
- Reduce program risk
- Ensure operational supportabilit
- Ensure design fo
- Assure affordability
- Demonstrate system integration, interoperability, and utility

Standards define interoperability

System Demonstration

- **Purpose: Demonstrate the ability of the system to operate in a useful way consistent with the validated KPPs.**
- **Key Activities:**
  - **Conduct extensive testing: developmental, operatio… …sting, as ap…**
  -
  - **D… envi…**
  - **Prepare RFP for Low Rate Initial Production**
  - **Prepare for Milestone C**
  - **Update: Information requirements**

Interoperability defined by standards is a key performance parameter.

Production & Deployment Phase

C

LRIP/IOT&E

Full-Rate Production & Deployment

FRP Decision Review

LRIP

Testing & evaluation conducted to ensure conformance to performance specs and interoperability standards for full rate production.

Enter:

Exit:
suitab... ...rate
production

Full-Rate Production & Deployment

...d LRIP (OSD T&E
...rograms) and LFT&E
...ed systems)
... Congress
...s: Full rate production.
... system. Start support.

Exit: Full operational capability; deployment compete

Operations and Support Phase*

- Emphasis shifts from design/development engineering to supporting the fielded system
- Operational units es lished & readiness monitored
- Test and evalu
- O
- Syst at end of its useful life

Using standard components makes it easier to support fielded systems and reduces DMS risk.

* Overlaps Production and Deployment Phase since items are deployed prior to the end of production, and must be sustained in the field

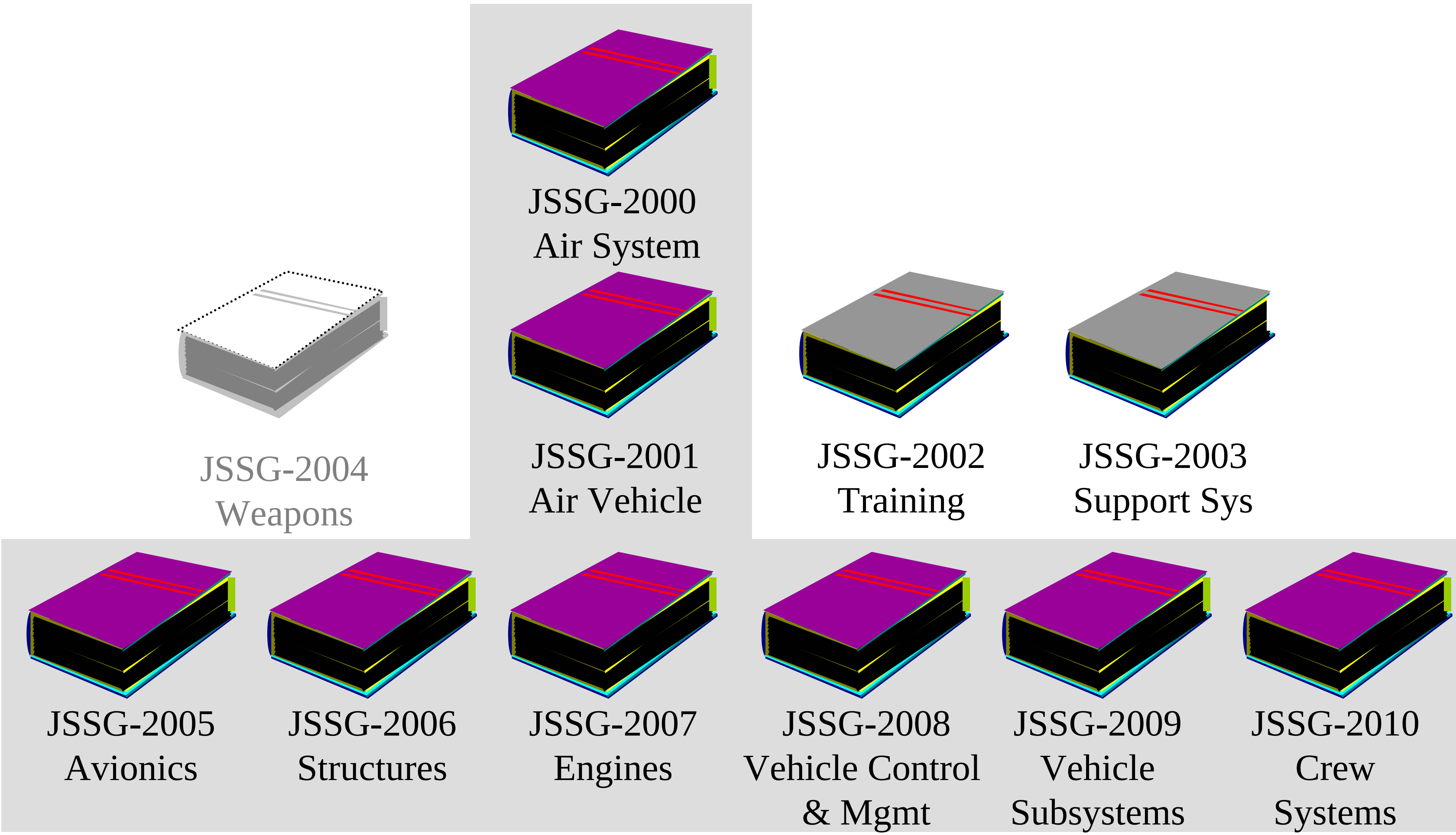
Which Standards?

- Def. Stdzn documents:

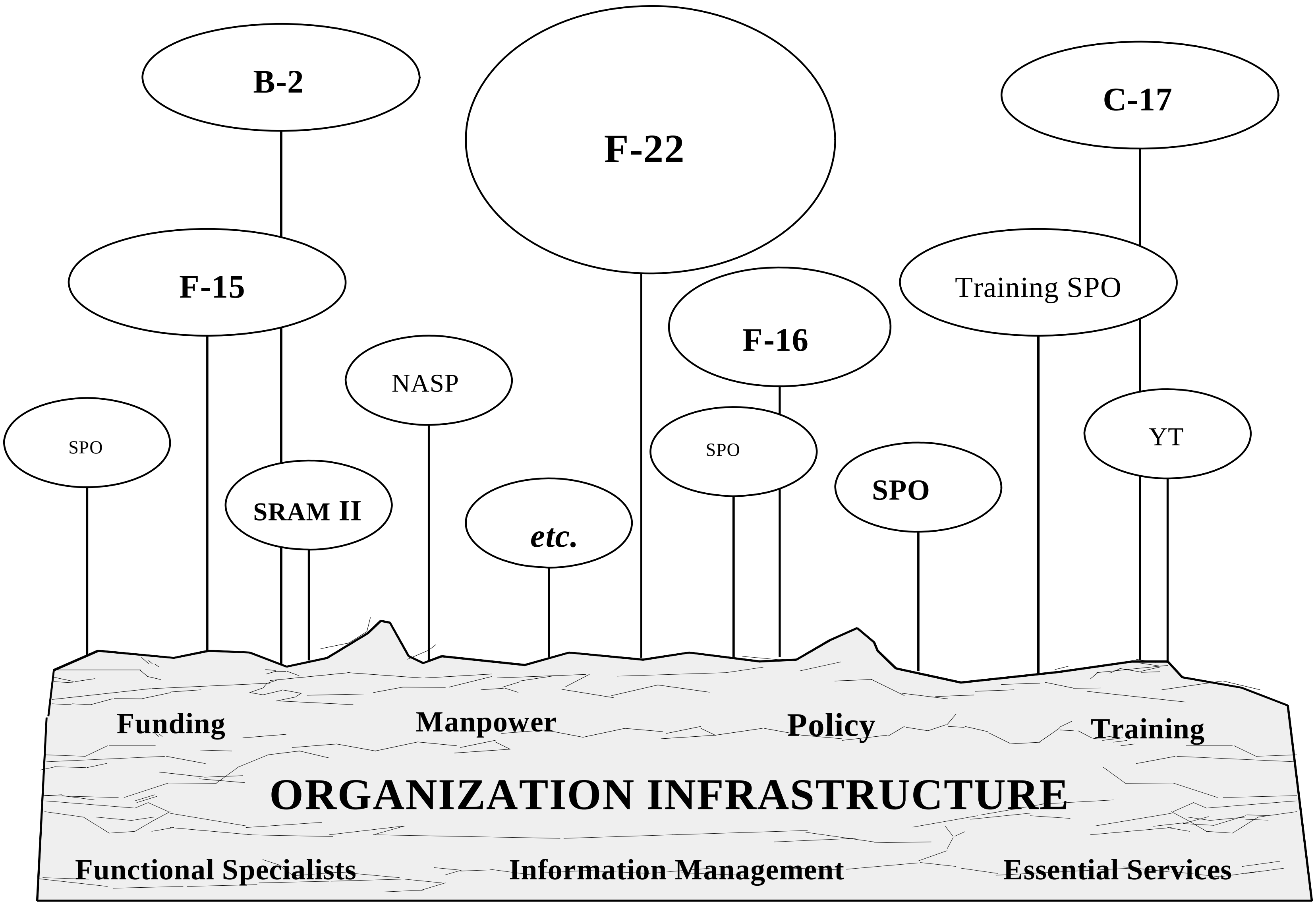
	Military	NGS	Total
Preparing Activity (speaks for DoD)	371	363	734
AF Custodian (speaks for AF)	6356	2742	9098
AF Review Activity (reviews for ASC)	1140	265	1405
	7867	**3370**	**11,207**

- Design Handbooks (17)
  - Shipping only 1- and 2-series documents today - on CD
- AF Characteristics Guides (6)
  - Shipping only - have only begun migration to CD
- Misc. support to other technical docs & publications
- Bottom Line: Each of the sectors (Space, Aeronautical Maritime…we all have a body of knowledge…standards.

Joint Service Specification Guides



The Bedrock that is ASC



Defense Standardization Program

- ASC/EN is responsible for development and maintenance of Engineering Standards under Defense Standardization Program (DSP)
  - Mandated by Public Law 82-436; DoD 5000.1&2; DoDD 4120.24; DoD 4120.3-M; AFPD 60-1; AFI 60-101
- Wing engineering tailors and applies standards
  - Responsible for application feedback to ASC/EN, who cares and feeds for the REO’s
- Industry design teams also use MIL specs and standards

It’s part of your day job!

"Notional" REO Month

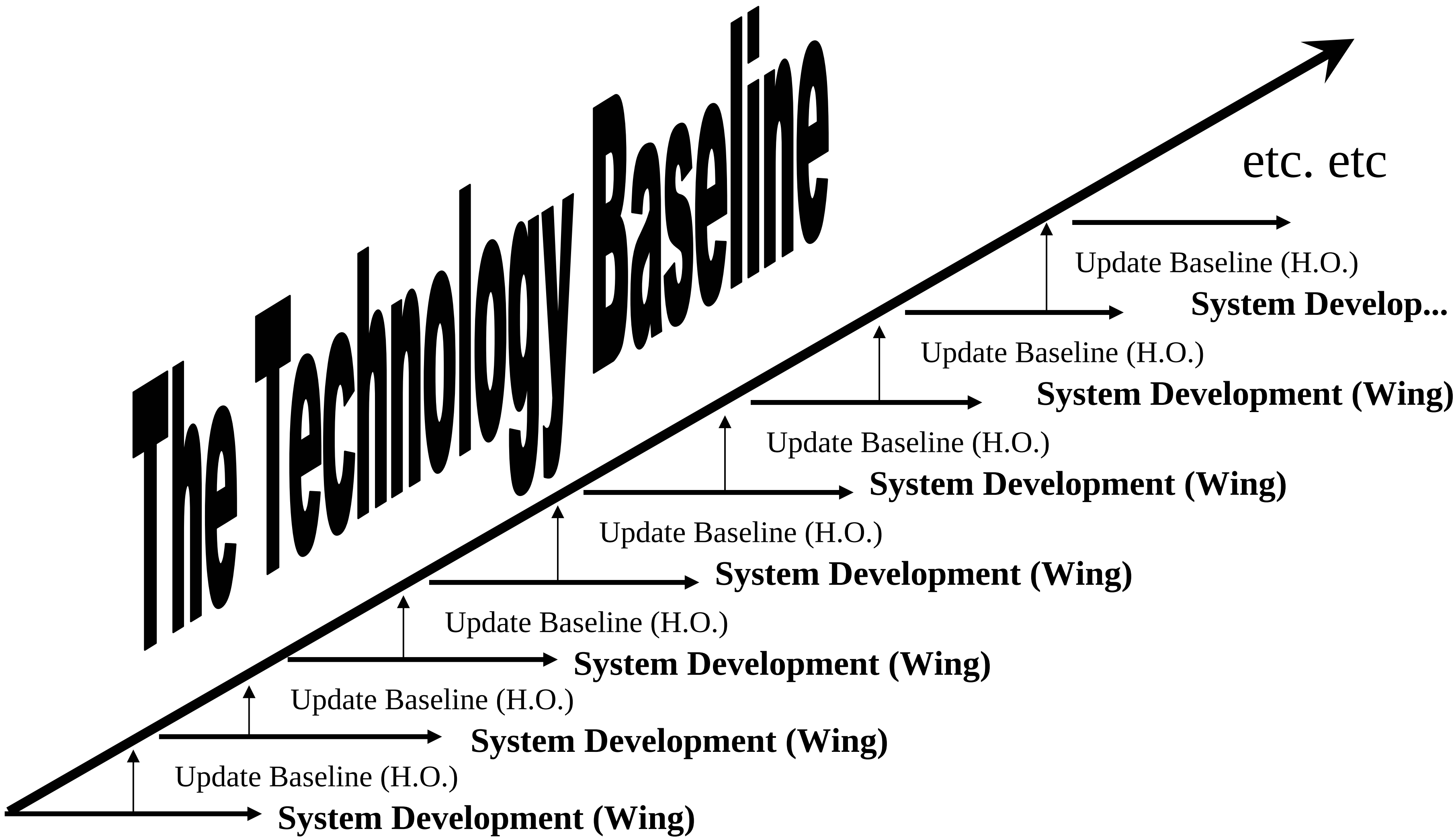
April 2003

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5 *ENF IMR*	6	7 *SPO Support*	8	9 *Int'l Stdzn Pre-Brief*	10
11	12 *TDY - Int'l Stdzn Working Group*	13	14	15	16 **Trip Report**	17
18	19	20 *SAE Symposium, San Fran*	21	22	23	24
25	26 **Trip Report**	27 *Brfg to YF*	28 *Revise JSSG-2010*	29	30	

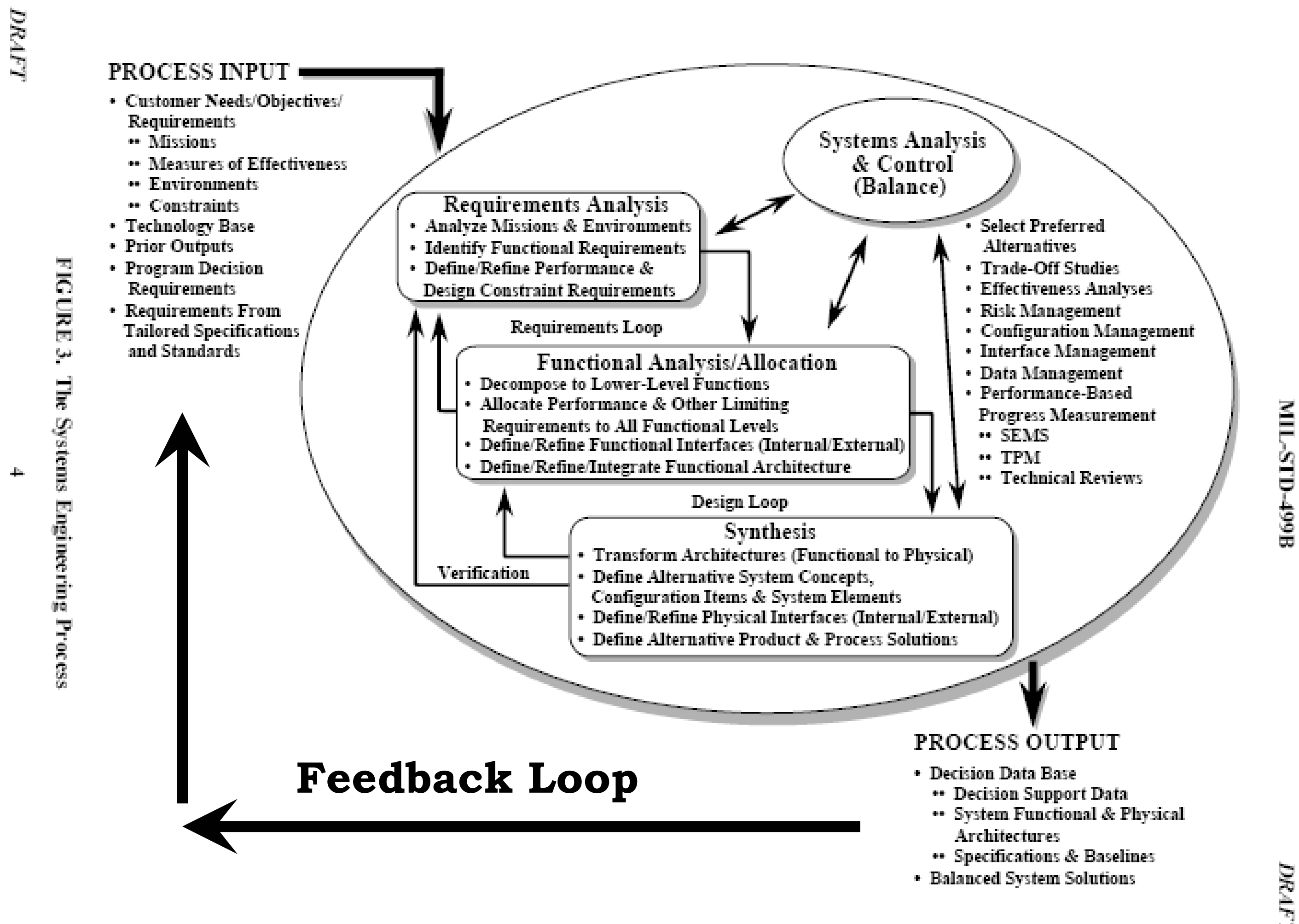
Next Month Reminders: Tech Report; Training ("Boomerang"); ASC Quality Symposium; TDY - WR-ALC

How Knowledge Works…

..or, why we document what we do!



Systems Engineering "Engine"



Benefits of the DSP

- Standards are “foundational” to all that we do
  - Measuring program execution, success and/or failure
  - Moving both the State-of-the-Art and Tried-and-the-True
  - Reducing risk in programs and the SE process
  - Providing “confidence” to those who actually <u>execute</u> the SE process
  - Documenting & Communicating Lessons Learned
  - Mentoring the Next Generation
  - Communicating technologies and strategies across entire sectors…forming a common understanding
  - ..Shall I continue…?

My Assertion…

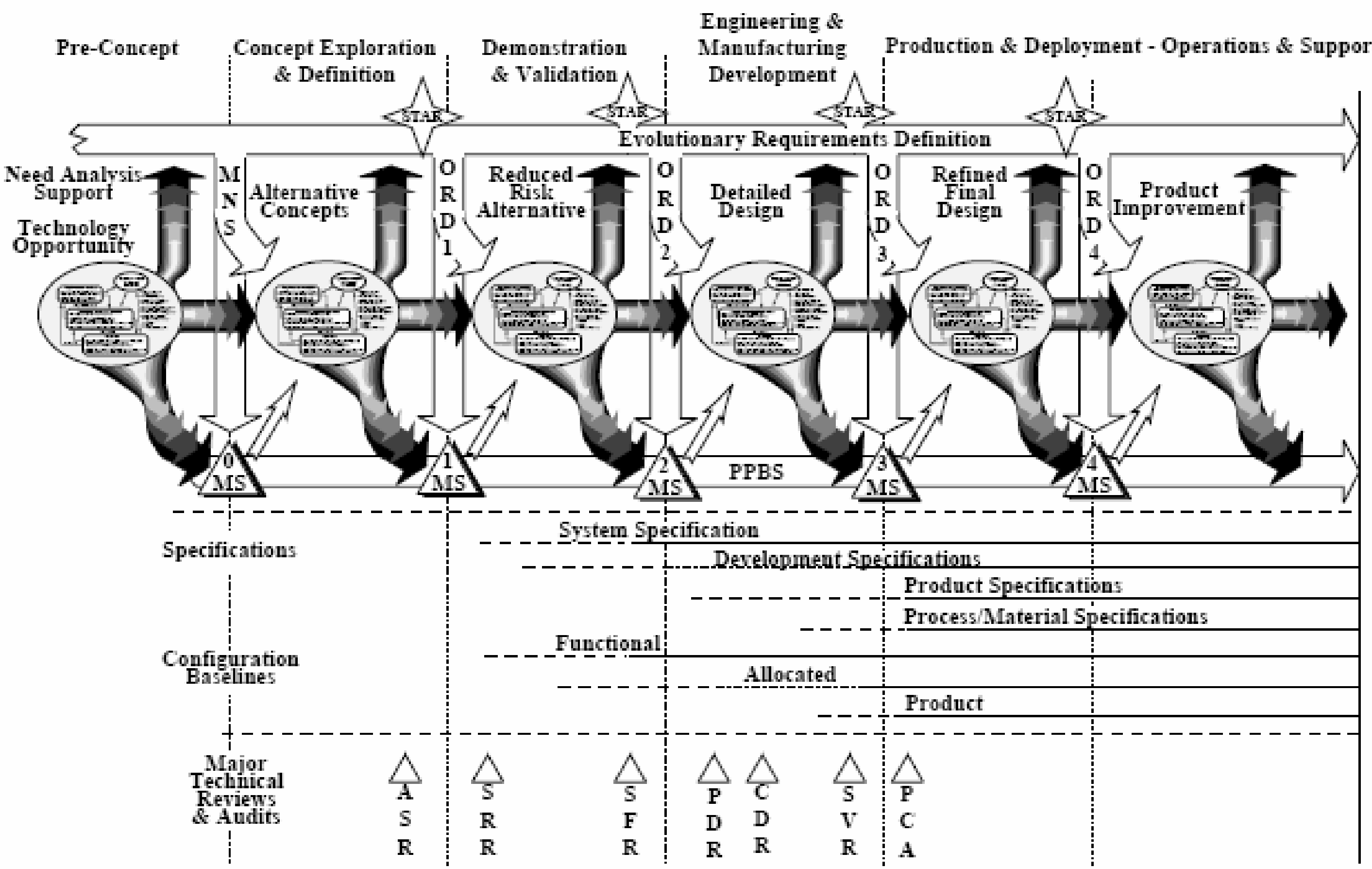
- Specs & Standards are not gone!
  - We are “down to” only 12,000 in the aero sector

- Spec & Standards, and all the work it takes to create them, coordinate them, update them, understand them, use them, is “foundational” to the execution of the SE process (not a “crutch!”)

- Development of, use of, translation of technical requirements is the heart of the technical portion of the SE process… ..as we revitalize SE, consider the role that specifications and standards play in the overall “business” of systems engineering.

Now then…let's paint this sucker!

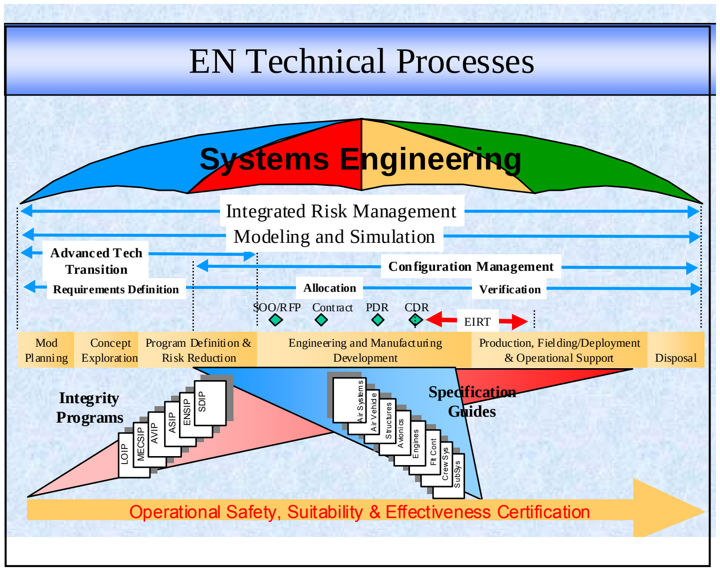
Back Up Material

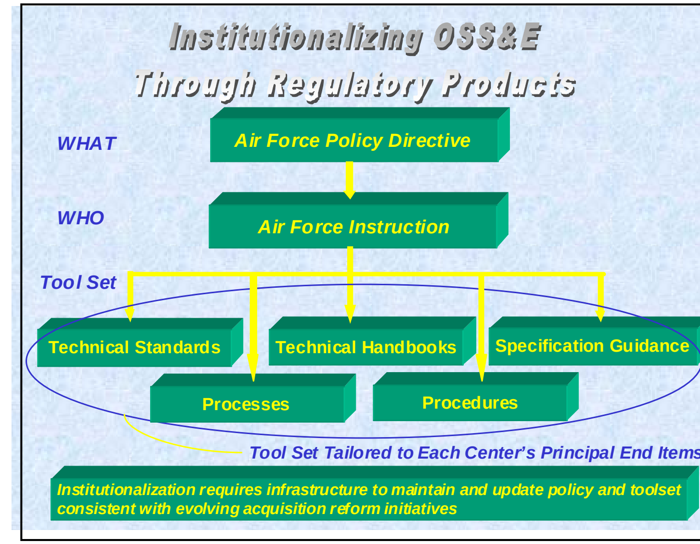


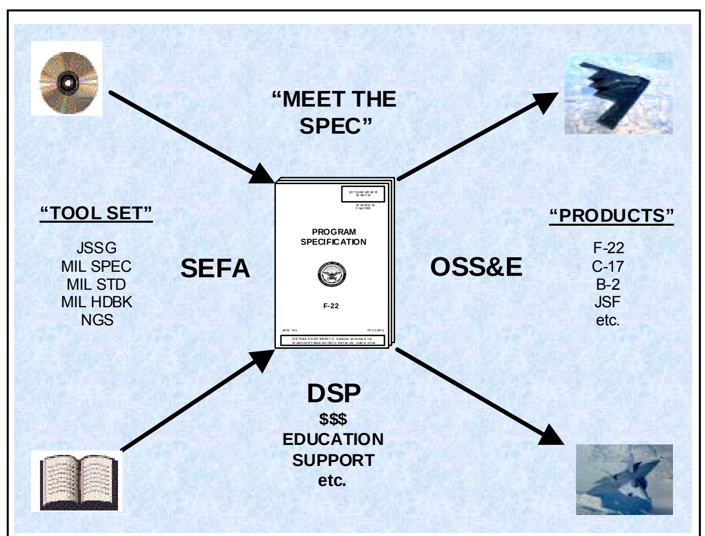
MNS	Mission Need Statement	ASR	Alternative Systems Review
MS	Milestone	CDR	Critical Design Review
ORD	Operational Requirements Document	PCA	Physical Configuration Audit
PPBS	Planning, Programming, and Budgeting System	PDR	Preliminary Design Review
STAR	System Threat Assessment Report	SFR	System Functional Review
		SRR	System Requirements Review
		SVR	System Verification Review

FIGURE 4. Example of a System Life Cycle

OSS&E "Toolset"







Air Force "Pre-Acquisition" SE:
Technical Planning and Investment to Inform the Decision-Making Process

Mr. Terry Jaggers, SES

Chief Engineer

Office of the Assistant Secretary of the Air Force (Acquisitions)

23 February 2007

Aero Sector’s JSSG’s

- The JSSGs assist in the development of effective program-specific specifications. Such specifications, which define the expectations for the product and the confirmation those expectations are met throughout development, form the basis to further refine product requirements, the significant accomplishments that must be achieved throughout development, the activities and schedule by which those accomplishments will be achieved, and the definition of the work to be performed in the conduct of those activities. Linking the product expectations to the work to be accomplished in development provides the basis for contracts which are both executable and enforceable.

A Convergence of Technologies for Better Software NOW!

Dottie Acton
Lockheed Martin IS&GS

Topics

- Two categories of software errors
- How technologies can help
- Who needs to be involved
- Some experiences
- Questions
- Backup charts with technology descriptions

Two Categories of SW Errors

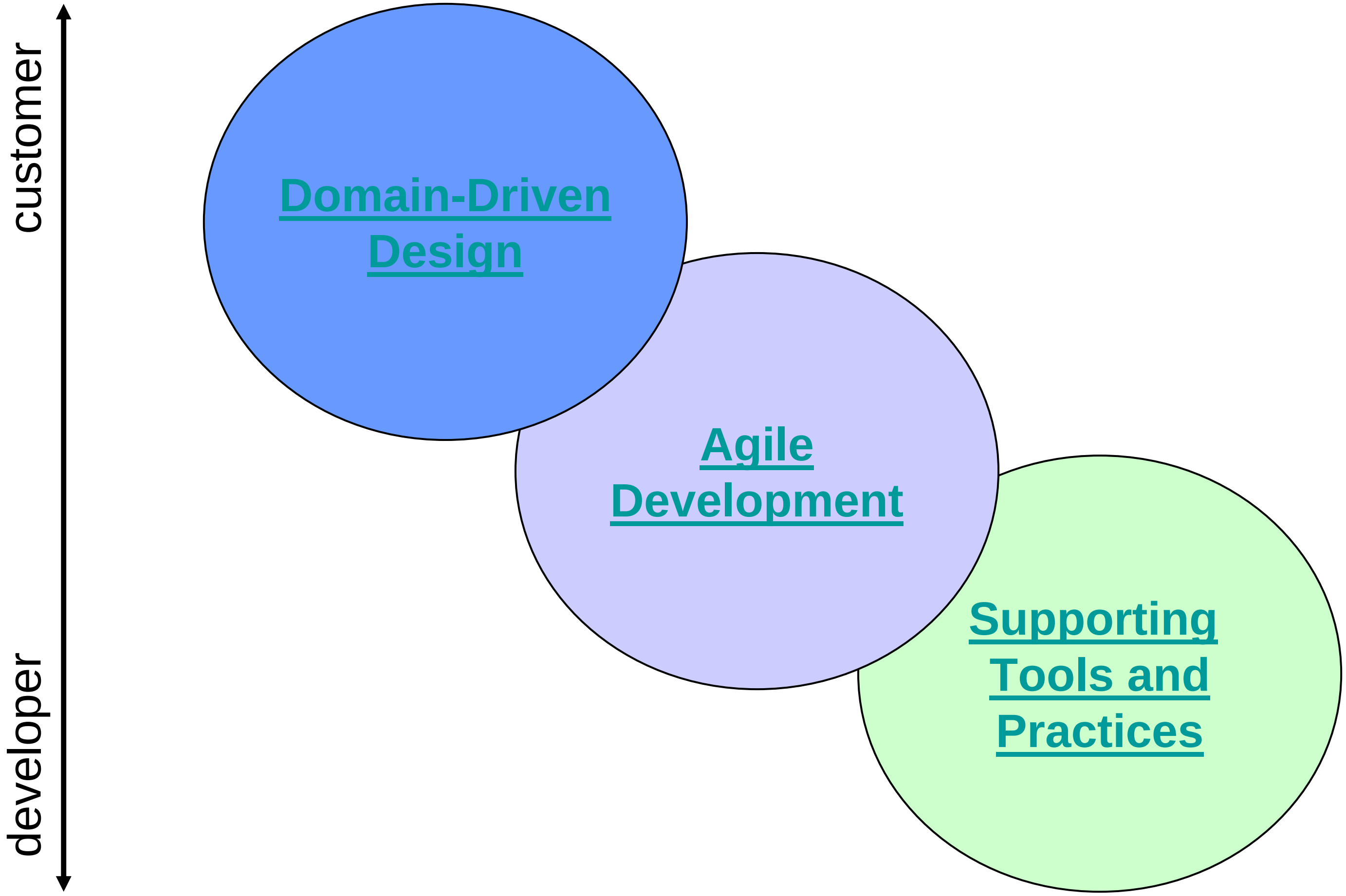
Solving the problem wrong

- Incorrect implementation of requirements (off by one bug, logic errors, etc)
- Bad coding practices that leave security holes
- Interface mismatches
- Delivering too late to be useful
- Un-maintainable code
- Poorly performing software
- Poor user interfaces

Solving the wrong problem

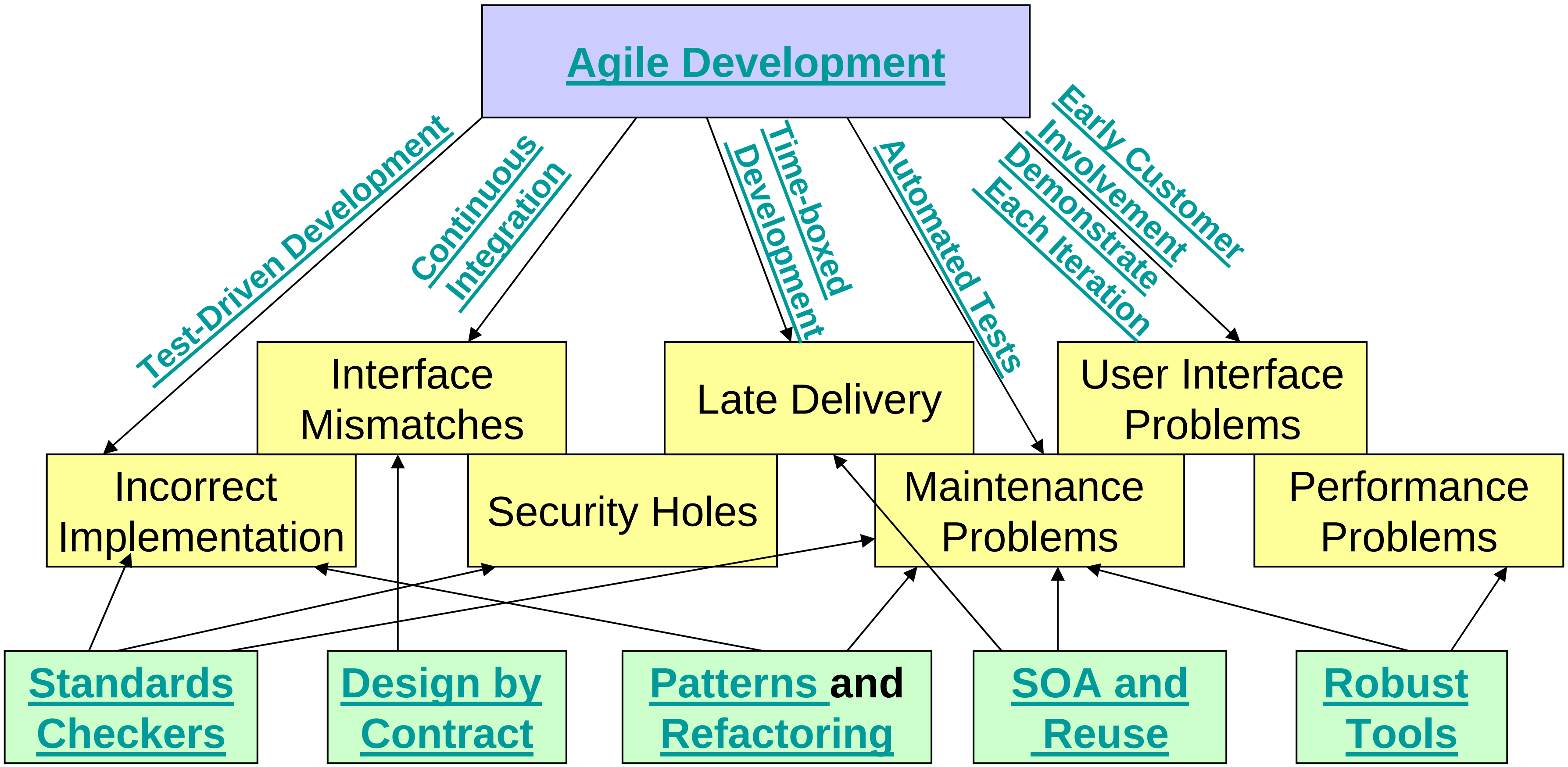
- Misinterpretation of requirements
- Missing requirements
- Unused capabilities
- Obsolete requirements
- Failing to recognize the existence of ‘wicked’ problems (the solution changes the nature of the problem)
- Focusing on generic or supporting domains rather than on the core domain

What are the Technologies?



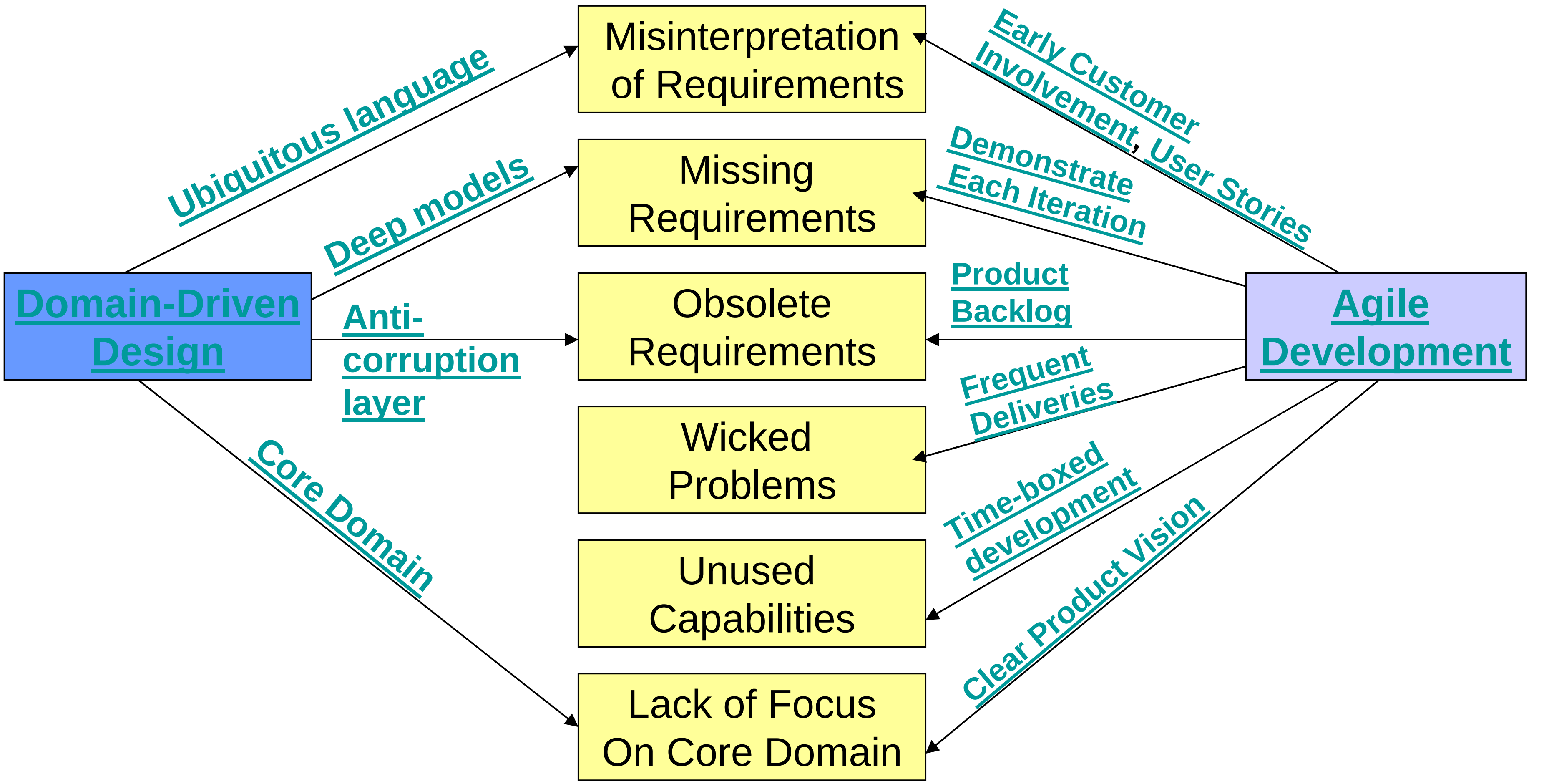
The Good News

Some technologies help with the issue of solving the problem wrong.



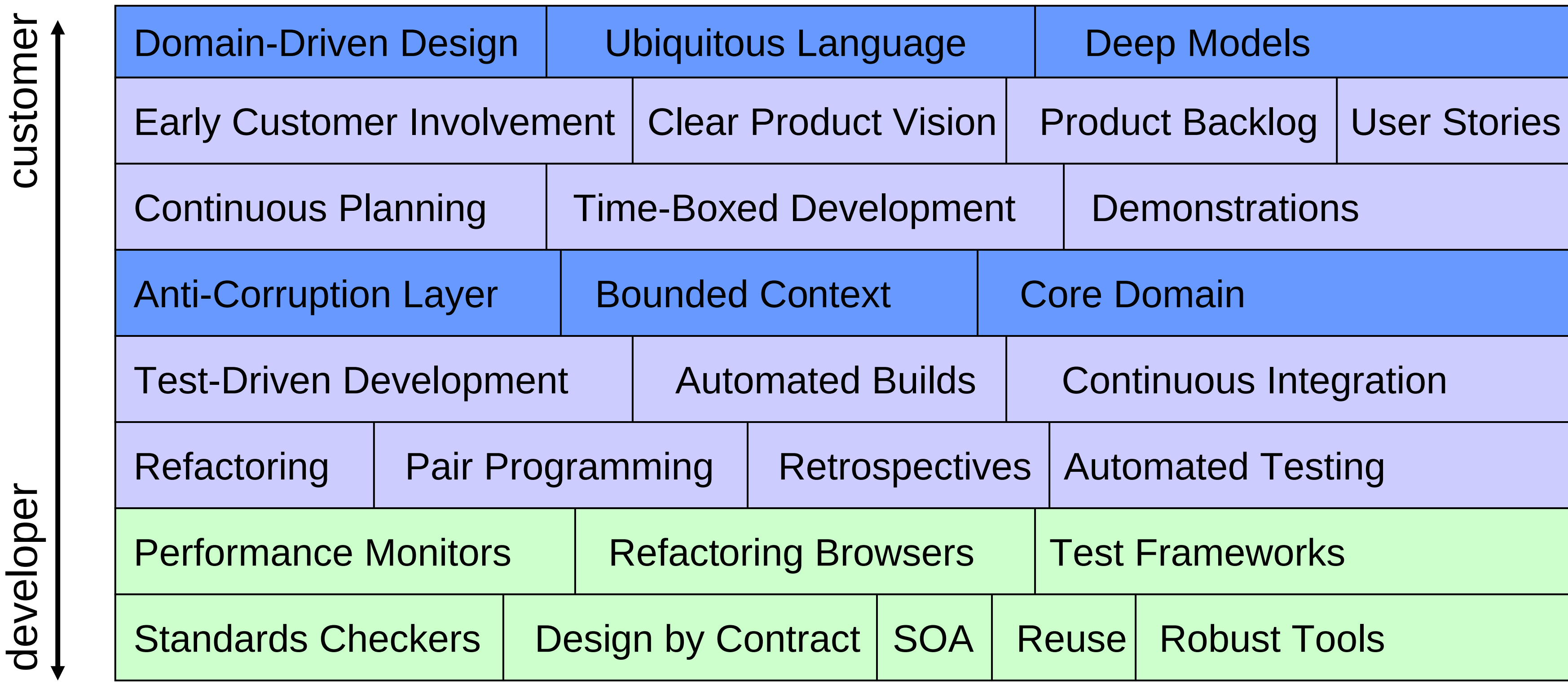
The Better News

Some technologies help with the more difficult issue of solving the wrong problem.



The Best News

- **The technologies are synergistic**



- **The barriers to adoption are relatively low**
  - **Good FOSS tool support to get started**
    - **COTS tools also available with additional capabilities**
  - **Adequate literature and experience base for training**

Who is Involved?

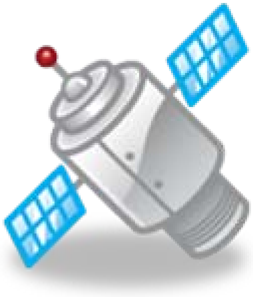
- Who is involved in making a change to agile and domain-driven design?
  - Everyone!
    - Customers, Users, Systems Engineering, Software Development, Test, Specialty and Support Disciplines, Management, etc.
  - Software developers usually like the change because it is a more natural way to solve problems
  - Systems engineers and managers sometimes have a harder time adapting
    - Managers fear the loss of the perception of being in control
    - Systems engineers sometimes struggle with the need to keep the big picture in mind while going deeper into selected areas for near-term development
- Benefits generally outweigh the negatives
  - Earlier feedback on requirements, architecture and design
  - Earlier visibility into problem areas
  - Good vehicle for transferring domain knowledge

Some Experiences (1)

- Program applying many of the practices
  - Program Characteristics:
    - Mission critical technical application, critical algorithms
    - Adopted both domain modeling and agile practices
    - Part of a larger system doing traditional development
  - Results:
    - High quality product, with good quality measurements
    - Able to make substantial change to add capability and improve performance with very little impact
    - Happy engineering team and happy customers
    - Practices spreading to other teams

Some Experiences (2)

- Program applying just a few of the agile practices
  - Program characteristics
    - New capability being added to large existing system
    - Many new developers
    - Experts still involved in previous release that was behind schedule
    - Focused on standards, daily status meetings, continuous integration, refactoring, automated builds
  - Results
    - New capability developed on time and budget
    - High quality code, based on early test results and independent quality assessment
    - Happy team and happy customers



Summary

- Domain-driven design and agile development together offer substantial opportunities for improving how we do business
  - Tool support is now robust enough to support iterative development
  - Adequate material is available for training
  - Substantial and sustained improvements are becoming evident

Questions

Backup Material

- Descriptions of the Key Technologies
  - Description
  - Benefits
  - References
    - Additional descriptive material
    - A book for further study

Agile Development

- Description:
  - An approach to software development that uses short, time-boxed iterations to support early delivery of the customer's highest value capability
    - Each iteration is potentially shippable
  - Agile approaches use continuous planning, analysis and design rather than completing those activities up-front, before development begins
    - Customer is involved in prioritizing and clarifying requirements throughout each iteration
  - Examples:
    - Scrum, XP, Disciplined Agility, FDD, Adaptive Project Management
- Benefits:
  - Produces early value for customers
  - Accommodates changing requirements
  - Improves quality and productivity
- References:
  - http://en.wikipedia.org/wiki/Agile_software_development
  - Agile Software Development: The Cooperative Game by Alistair Cockburn

Test-Driven Development

- Description:
  - An approach to development that uses tests to drive the production of SW
  - Write a test, write the code, run the test, refactor
  - Examples:
    - Test frameworks include the xUnit family of FOSS tools (JUnit, cppUnit, nUnit, etc) as well as commercially available tools
- Benefits:
  - Produces high quality code with good interfaces and few dependencies, which improves the maintainability of the system
  - Makes future changes easier since all code has a suite of tests
- References:
  - http://en.wikipedia.org/wiki/Test-driven_development
  - Test-Driven Development: By Example by Kent Beck

Continuous Integration

- Description:
  - With continuous integration, developers check in their code several times a day, as soon as they complete each small chunk of functionality
  - When the code is checked in, a series of automated tests are run to ensure that both the new code and the existing code base function as expected
- Benefits:
  - Defects are discovered soon after they are introduced, so they are easier to find and fix
  - Fewer unpleasant surprises late in development
- References:
  - http://en.wikipedia.org/wiki/Continuous_integration
  - Continuous Integration: Improving Software Quality and Reducing Risk by Duvall, Matyas and Glover

Time-Boxed Development

- Description:
  - Each short iteration is scheduled for a specified duration – usually from 2-4 weeks
  - If the scheduled work cannot be completed, it is deferred to the next iteration
- Benefits:
  - Establishes a project rhythm that improves productivity
  - Provide early and frequent status based on working code
  - Forces hard choices about capability
    - The content must be allowed to change since schedule and quality are fixed
- References:
  - http://en.wikipedia.org/wiki/Timebox
  - Agile Project Management: Creating Innovative Products by Jim Highsmith

Automated Tests

- Description:
  - Test automation can occur at any level of testing
    - Unit test automation is supported through test frameworks like JUnit
    - Both FOSS and COTS products are available for automating aspects of higher level testing
  - Automated tests are designed to be run frequently, so they must be fast and free of side effects
    - Usually automated unit tests are run as an integral part of development (see TDD) and each time the code is checked into the CM system
- Benefits
  - Improved feedback to the developer and increases the quality of changes to the code
  - Automated tests are especially valuable for regression testing
  - Provide a safety net for future changes
- References:
  - http://en.wikipedia.org/wiki/Automated_testing
  - http://www.junit.org/
  - Fit for Developing Software: Framework for Integrated Tests by Rick Mugridge and Ward Cunningham

Early Customer Involvement

- Description:
  - Customers create and prioritize items in the product backlog
  - Daily interaction between customer and developers both clarifies requirements details and allows for the deeper understanding that helps manage the complexity associated with most domains
  - Examples:
    - Business person working with developers to clarify requirements for a payroll system or invoice system
    - Hardware engineer working with developers to clarify interactions between new hardware and controlling software
    - Systems engineers working with developers to develop algorithms for scheduling access to specific resources
- Benefits:
  - Reduces the need to capture requirements detail early in the life cycle
- References:
  - http://en.wikipedia.org/wiki/Extreme_Programming_Practices#Whole_team
  - Extreme Programming Explained: Embrace Change (Second Edition) by Kent Beck and Cynthia Andres

Demonstrate Each Iteration

- Description:
  - At the end of each 2-4 week iteration, the features developed during that iteration are demonstrated to the customer
    - Customer feedback drives priorities for future iterations
- Benefits:
  - Promotes better understanding of additional or different needs
  - Working code demonstrates real progress
- References:
  - http://www.scrumforteamsystem.com/ProcessGuidance/Process/SprintReview.html
  - Agile Software Development with Scrum by Ken Schwaber and Mike Beedle

User Stories

- Description:
  - Short descriptions of features that can be implemented in 2 days to 2 weeks
  - Three pieces to a user story
    - Short written description
    - Conversations about the story to flesh out the details
    - Tests that convey and document details and that can be used to determine when a story is complete
- Benefits:
  - Provide a good basis for estimating size as well as a mechanism for understanding user needs
  - Force a shift to verbal communication for feature details, which is much higher band-width and supports rapid feedback cycles
  - The tests associated with the stories provide executable documentation of user requirements
- References:
  - http://en.wikipedia.org/wiki/User_story
  - User Stories Applied for Agile Software Development by Mike Cohn

Product Backlog

- Description:
  - A product backlog is a prioritized list of features desired for a product
    - Grows and changes over time as more is learned
    - Scope line shows how much can be accomplished with current funding
  - Prioritization is primarily based on customer needs, but must also consider technical dependencies
  - Commercial and FOSS tools are available to help manage both the product backlog and iteration backlogs
- Benefits:
  - Prioritized development of functionality maximizes customer value
  - Allows users to add, subtract or change features based on new needs
  - Scope line provides on-going visibility into features that can be developed with current funding
- References:
  - http://www.mountaingoatsoftware.com/product_backlog
  - Scaling Software Agility: Best Practices for Large Enterprises by Dean Leffingwell

Frequent Deliveries

- Description:
  - Short iterations allow early delivery to customer
    - Each iteration should be potentially shippable
  - Often multiple iterations are grouped for delivery to customer
    - Functionality is complete with each iteration, but there may be need for a ‘hardening’ iteration before shipment to address publication of user documentation, final system tests, etc
- Benefits:
  - Allows customers to get early benefit from the system
  - Use of the system in the customer environment gives improved opportunities to discover ‘the real requirements’
- References:
  - http://www.stsc.hill.af.mil/CrossTalk/2002/10/mccabe.html
  - Lean Software Development, An Agile Tool Kit by Mary and Tom Poppendieck

Clear Product Vision

- Description:
  - Product vision is established early to guide future development efforts
    - Essential when requirements are not fully detailed initially
  - One technique to establish the vision is to design the ‘box’ for the product
    - Differences between boxes designed by different teams can illuminate areas of disagreement on product priorities
- Benefits:
  - Helps focus customers and developers on the essentials of the product
  - Guides lower level implementation decisions
- References:
  - http://www.innovationgames.com/game/PRODUCTBOX.aspx
  - Agile Project Management: Creating Innovative Products by Jim Highsmith

Automated Builds

- Description:
  - Goal is to reduce the build process to a simple us-of-a-button action
    - Every programmer can perform a build whenever it is needed
      - Incremental builds can help make this a reality
    - With today's tools it is possible for even the largest systems to build multiple times a day
  - Enables effective Test-Driven Development
- Benefits:
  - Reduces time programmers spend on repetitive build tasks
  - Improves ability to run tests for every change, which improves quality and productivity
- References:
  - http://www.electric-cloud.com/solutions/agile_software_development.php
  - Integrating Agile Development in the Real World by Peter Schuh

Pair Programming

- Description:
  - Two individuals work side-by-side, sharing a single workstation, to design or code
  - Pairing with testers and engineers can be beneficial when requirements clarification is needed
- Benefits:
  - Provides a real-time peer review
  - Good mechanism for knowledge transfer
  - Improves code quality
- References:
  - http://en.wikipedia.org/wiki/Pair_programming
  - Pair programming Illuminated by Laurie Williams and Robert Kessler

Retrospectives

- Description:
  - At the end of each iteration, each team meets to celebrate the completion of the iteration and to capture lessons learned for the next iteration
  - Three topics to consider
    - What worked well and should be continued
    - What should the team stop doing
    - What needs to be done differently
- Benefits:
  - Identifies areas for improvement in the next iteration
  - Improved morale when team members know that the are listened to
- References:
  - http://www.retrospectives.com/
  - Agile Retrospectives, Making Good Teams Great by Esther Derby and Diana Lawson

Domain-Driven Design

- Description:
  - A way of accelerating software projects that have to deal with complex domains
  - Fundamental principles
    - The primary focus should be on the domain and domain logic
    - Complex domains should be based on a model
  - Agile approaches enable domain-driven design
    - Work with customers to develop models that reflect domain concepts
    - Provide rapid feedback to clarify complex areas
- Benefits:
  - Deeper understanding of the domain
  - Better communication between developers and domain experts
  - Ability to make breakthroughs at a faster pace
- References:
  - http://domaindrivendesign.org/
  - Domain-Driven Design: Tackling Complexity in the Heart of Software by Eric Evans

Ubiquitous Language

- Description:
  - A common language, based on the domain model, that serves as a communication vehicle between engineers, developers and domain specialists
    - Use of model-based terms in all project communication facilitates deeper understanding of the domain by everyone
    - One of the best ways to refine a model is to explore with speech, trying out loud various constructs from possible model variations
- Benefits:
  - Improved communication, which results in better models and better software
  - Helps in the discovery of hidden concepts
    - Often these arise in areas where the language does not flow smoothly
- References:
  - http://domaindrivendesign.org/discussion/messageboardarchive/UbiquitousLanguage.html

Deep Models

- Description:
  - An incisive expression of the primary concerns of the domain experts and their most relevant knowledge
    - A deep model sloughs off superficial aspects of the domain and naive interpretations
    - A deep model distills the most essential aspects of a domain into simple elements that can be combined to solve the important problems of the application
- Benefits:
  - Deep models enable acceleration of discovery and innovation within a domain
  - Keeps entire project on the same page
- References:
  - Domain-Driven Design: Tackling Complexity in the Heart of Software by Eric Evans

Core Domain

- Description:
  - The distinctive part of the model, central to the user's goals, that differentiates the application and makes it valuable
    - Efforts to refine and distill models should be focused on the core domain
- Benefits:
  - Identification of core, supporting and generic domains can help drive the company's strategy for what they develop, outsource or purchase
  - Helps identify the impact of changes
- References:
  - Domain-Driven Design: Tackling Complexity in the Heart of Software by Eric Evans

Bounded Context

- Description:
  - Defines the scope of each domain model
    - Identifies what has to be consistent and what can be developed independently
    - Defines the boundaries for continuous integration
  - Relationships between contexts can take multiple forms
    - Shared kernel, customer/supplier development teams or conformist
- Benefits:
  - Clearly identifies boundaries, which improves ability to integrate across teams
  - Understanding of relationships between contexts drives appropriate program behavior
- References:
  - Domain-Driven Design: Tackling Complexity in the Heart of Software by Eric Evans

Anti-Corruption Layer

- Description:
  - Allows new models to interface with legacy systems, without losing the clarity needed for deep modeling
  - Creates an isolation layer so that the new model can avoid corruption caused by needing to adapt to the semantics of the old system
  - Can be implemented by a combination of façade and adapter patterns, but it is more sophisticated than either of those
- Benefits:
  - Keeps one side of a bounded interface from leaking into the other, so the new models are not corrupted
    - Provides a translation between parts of the system that adhere to different models
- References:
  - http://domaindrivendesign.org/practitioner_reports/peng_sam_2007_06.pdf

Design by Contract

- Description:
  - An approach to software design that makes pre- and post-conditions explicit for each public method
    - Uses asserts (or equivalent) to enforce the contracts
  - Defensive programming is used at system boundaries, but not for interfaces within a boundary
- Benefits:
  - Interface mismatches are detected immediately, rather than indirectly through the errors that result from the mismatch
- References:
  - http://en.wikipedia.org/wiki/Design_by_Contract
  - Object-Oriented Software Construction, Second Edition, by Bertrand Meyer

Patterns

- Description:
  - A pattern is a repeatable solution to a common problem in software design
    - Captures lessons learned about use of the solution in various situations
  - Catalogs of patterns exist at various levels, including architecture patterns and design patterns
- Benefits:
  - Leads to higher quality designs that are easier to maintain with fewer dependencies
  - Enhanced communication of intent, based on the pattern selected
    - The pattern name conveys a lot of information in a few words
- References:
  - http://en.wikipedia.org/wiki/Design_pattern_%28computer_science%29
  - Design Patterns: Elements of Reusable Object Oriented Software by Gamma, Helm, Johnson and Vlissides

Refactoring

- Description:
  - An approach that systematically changes the internal structure of code without changing its behavior
  - An integral part of test-driven development
  - Often done prior to making major changes to code, in order to make it easier to make the changes
    - Each small change is tested so any errors are detected immediately
- Benefits:
  - Cleaner code, fewer dependencies, fewer defects
  - Supported by refactoring browsers, so it is a relatively safe way to make code changes
- References:
  - http://en.wikipedia.org/wiki/Refactoring
  - Refactoring: Improving the Design of Existing Code by Martin Fowler

SOA and Reuse

- Description:
  – SOA is an architectural style where existing or new functionalities are grouped into atomic services
    - The goal of SOA is to allow fairly large chunks of functionality to be strung together to form ad-hoc applications which are built almost entirely from existing software services
- Benefits:
  – Supports large-grained reuse of independently developed services
    - Enhanced productivity and quality through reuse
  – Enables increased focus on the core domain
- References:
  – http://en.wikipedia.org/wiki/Service_oriented_architecture
  – Service-Oriented Architecture: Concepts, Technology and Design by Thomas Erl

Robust Tools

- Description:
  - There are many tools available today that actually help in the development of software
    - Standards checkers, and standards checking services, Refactoring browsers, Test frameworks, Performance monitors, Modeling tools, especially those with reverse engineering capabilities
  - Need to make sure that the selected tools do not drive extra work
- Benefits:
  - Improved developer productivity
  - Improved quality
  - Enablers for iterative development – manual processes not adequate to support short development cycles
- References:
  - http://www.opensourcetesting.org/functional.php
  - http://www.opensourcetesting.org/unit_java.php
  - http://www.ddj.com/TechSearch/searchResults.jhtml;jsessionid=MPJGHOHFWKVKCQSNDLOSKH0CJUNN2JVN?queryText=tools

Lockheed Martin Aeronautics Company Approach to Solving Development Program Issues

John E. Weaver

Christopher L. Blake

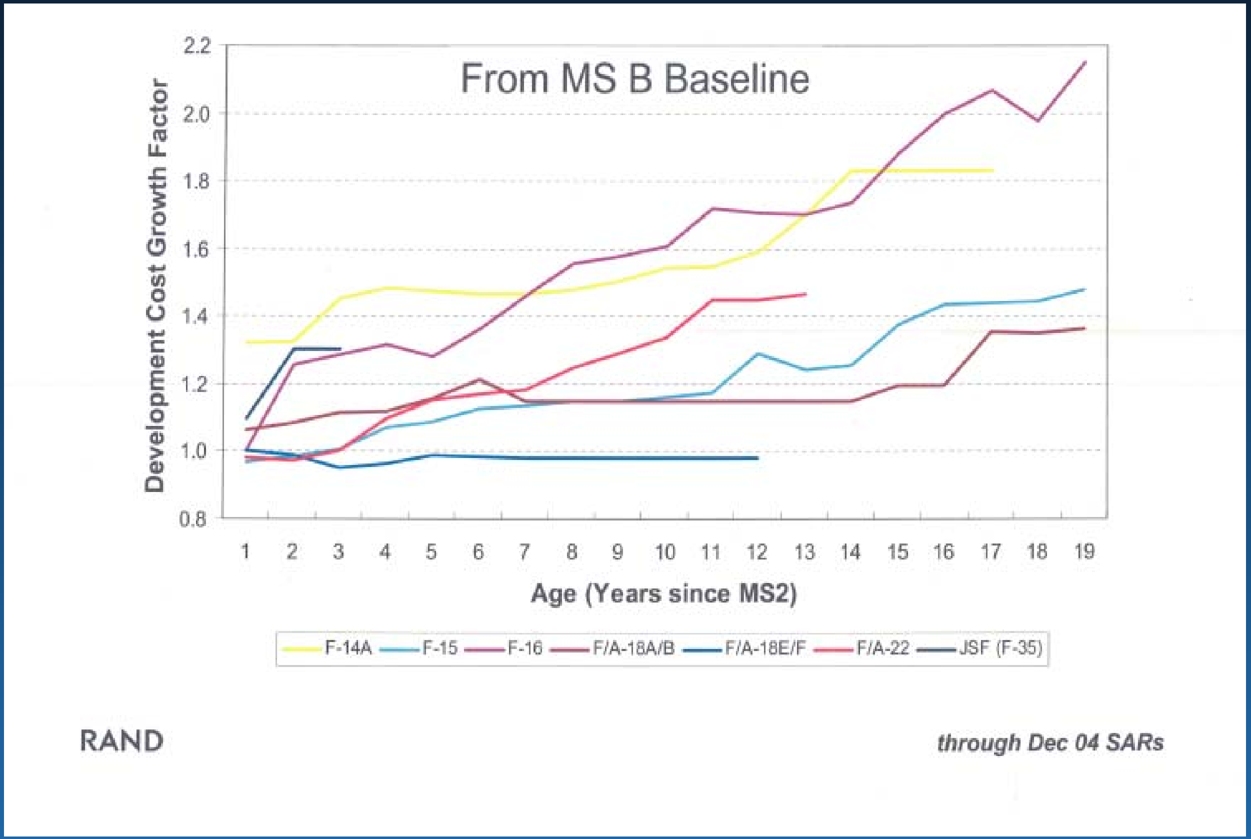
LM Aero Approach to Systemic Development Issues

- Industry Trend of Performance on Aircraft Development Programs
- What is in the Future
- What LM Aero is Doing
- Conclusions

History of Development Performance

DoD -- "Since 2004, total costs for a common set of 64 major weapon systems under development have grown in real terms by 4.9% per year -- costing $<u>165 billion</u> ($BY07) more in 2007 than planned for in 2004"

GAO 2007



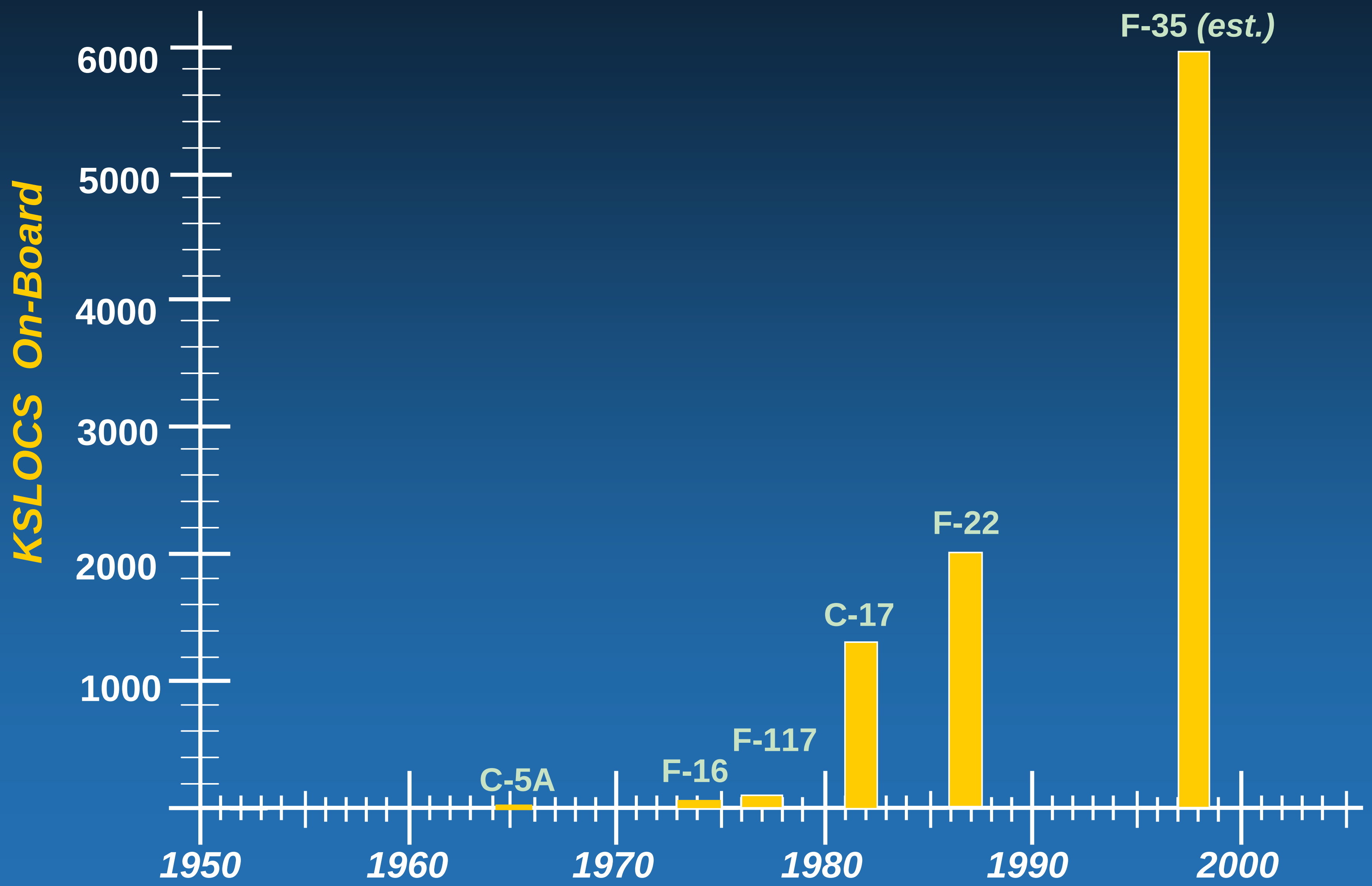
AF -- 1.5 development cost growth ratio -- ongoing programs 5 yrs beyond M/S-B -- *No improvement in 3 decades*

RAND 2005

What is in the Future

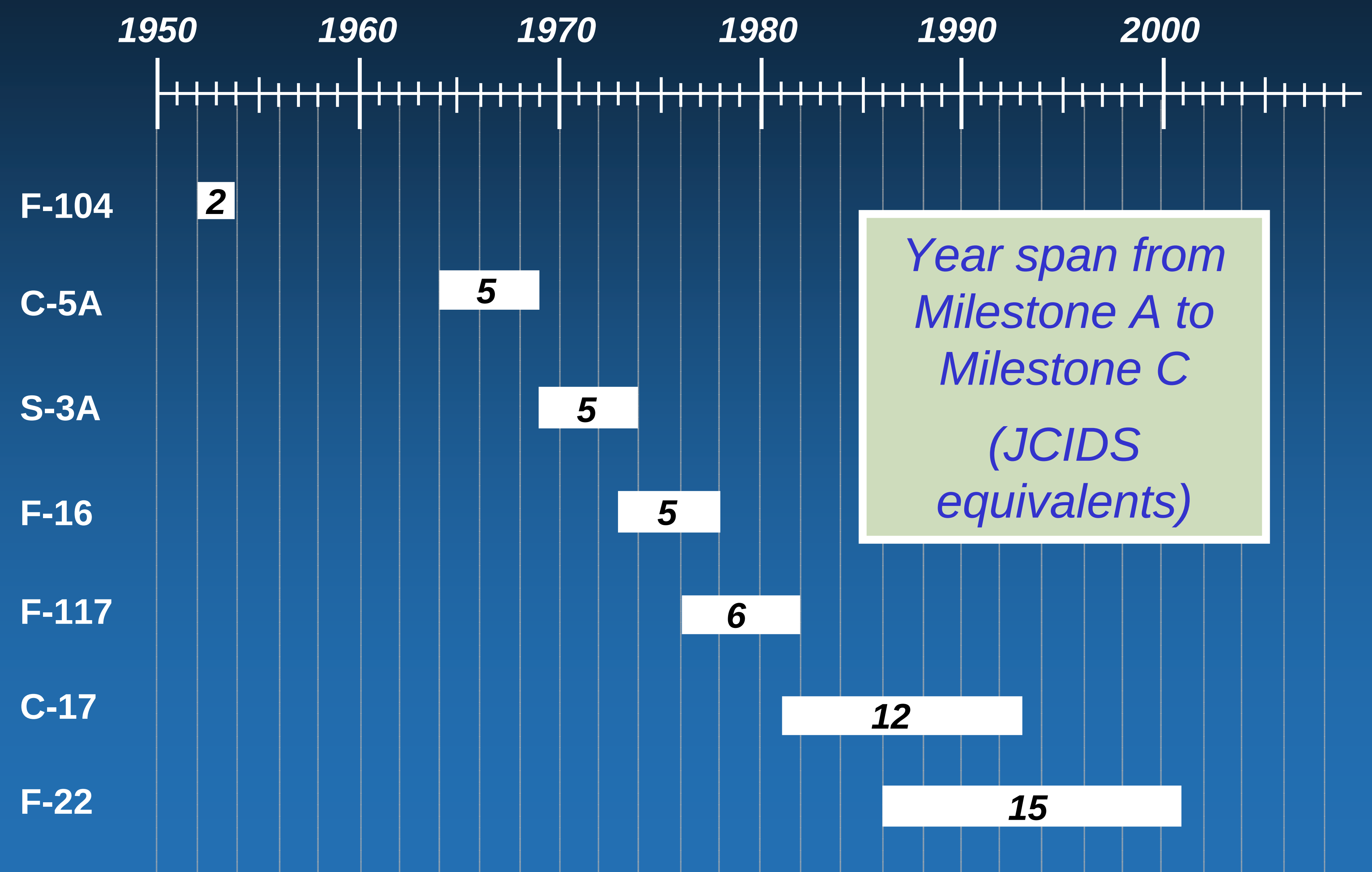
- New Military Aircraft are Going to be More Complex.
- New Aircraft Development Spans are Monotonically Increasing.
- Our Future Workforce will be Less Experienced and More Inclined to Change Employers.

Aircraft Are Becoming More Complex



Lockheed Martin Aeronautics Company

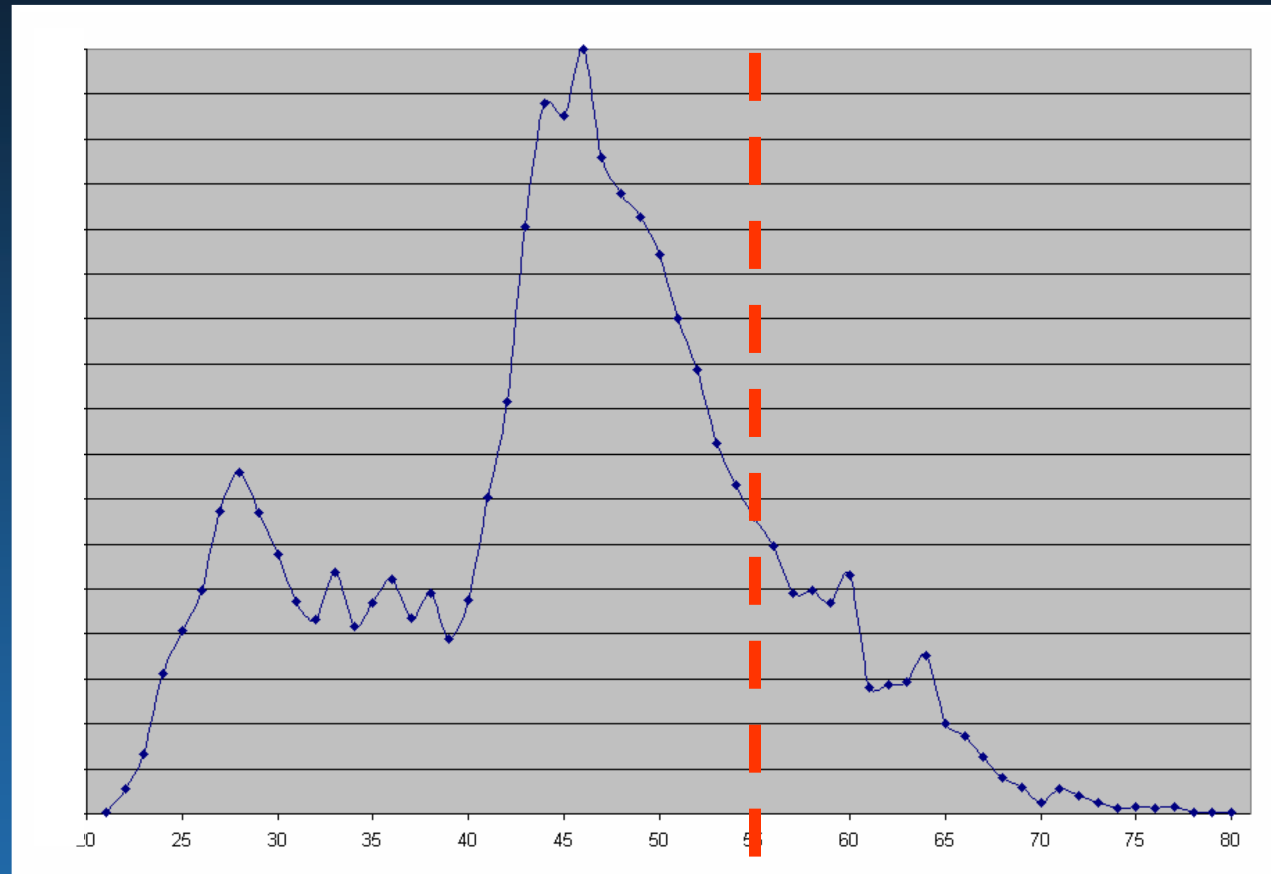
Length of A/C Development Programs



Typical Aerospace Company Age Profile

Relative Number of Employees

Median Age: Late 40's



Age

Retirement Eligibility

Most Technical Professionals Over 50 have Worked on 3 or More Aircraft Development Programs

Root Causes for the Performance

- **Poor Quality Requirements and Requirements Management Resulting in Designs that do not Fulfill Customer Expectations**
  - *Functional Baseline*
  - *Allocated Baseline*
  - *Active Management of Allocations*
- **Poor Technical Planning Prior to M/S B Resulting in Unrealistic Schedules and Unexecutable Plans**
  - *Level of Detail*
  - *Historical Bases for Spans*
  - *Linkage of Higher and Lower Level Planning to Key Integration Events*
  - *Interactively Versus Prescriptively Determined Key Program Event Dates*

Root Causes for the Performance - Continued

- **Limited Experience of Program Technical Personnel and Ineffective Command Media**
  - *New Inexperienced IPT Leads are Place in Critical Decision Making Roles without Adequate Help.*
  - *General, High Level Command Media is not Readily Useable by People Working on Development Programs*

- **Inability to Effectively and Objectively Assess Technical Performance, Quality and Integrity in a Timely Manner**
  - *Need for and Type of Corrective Action is Identified Too Late to Avoid Serious Consequences*
  - *Incomplete, Inconsistent and Inappropriate Metrics Incentivize the Wrong Actions*

To Say "Poor Systems Engineering" Doesn't Help

What Lockheed Martin Aeronautics is Doing

- **Developing a Systematic Method to Define, with the Customer, Functional Baseline Requirements Much Earlier in the Acquisition Lifecycle**
- **Modeling the Aircraft Development Process in Sufficient Detail to Identify the Work Products, the Sequence in which they are Produced and the Work Product Handoffs**
- **Collecting the Best Practice Information for Creating Each Work Product and Making this Information Available to Those People Working on Development Programs.**
- **Instituting a Process to Independently Assess the Adequacy of Each Work Product Before it is Released and Defining Valid Metrics to Assess Real Performance in Every Area of the Program**

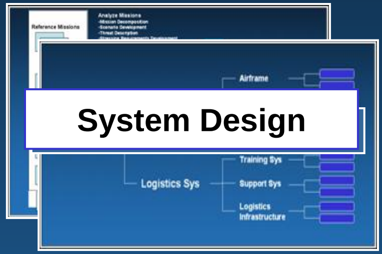
Approach Applies to Pre-contract, Post-award Planning, and Program Execution

- High level system design using a standard methodology
- Scope of work to be planned

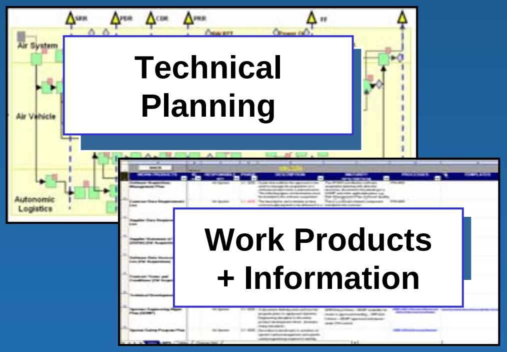
Proposal Submittal

B **Contract Award / ATP**

Program Baseline

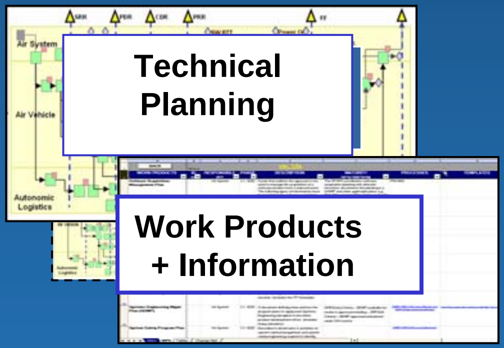


Define Work Sequence & Output

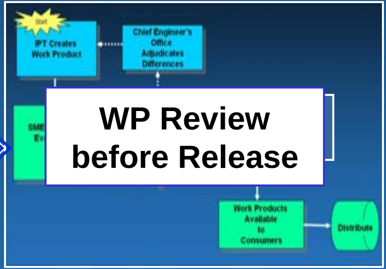


- Standard Tech Plan & WPS provides starting point
- Top – level definition applied to the specific program

Refine Work Sequence & Output

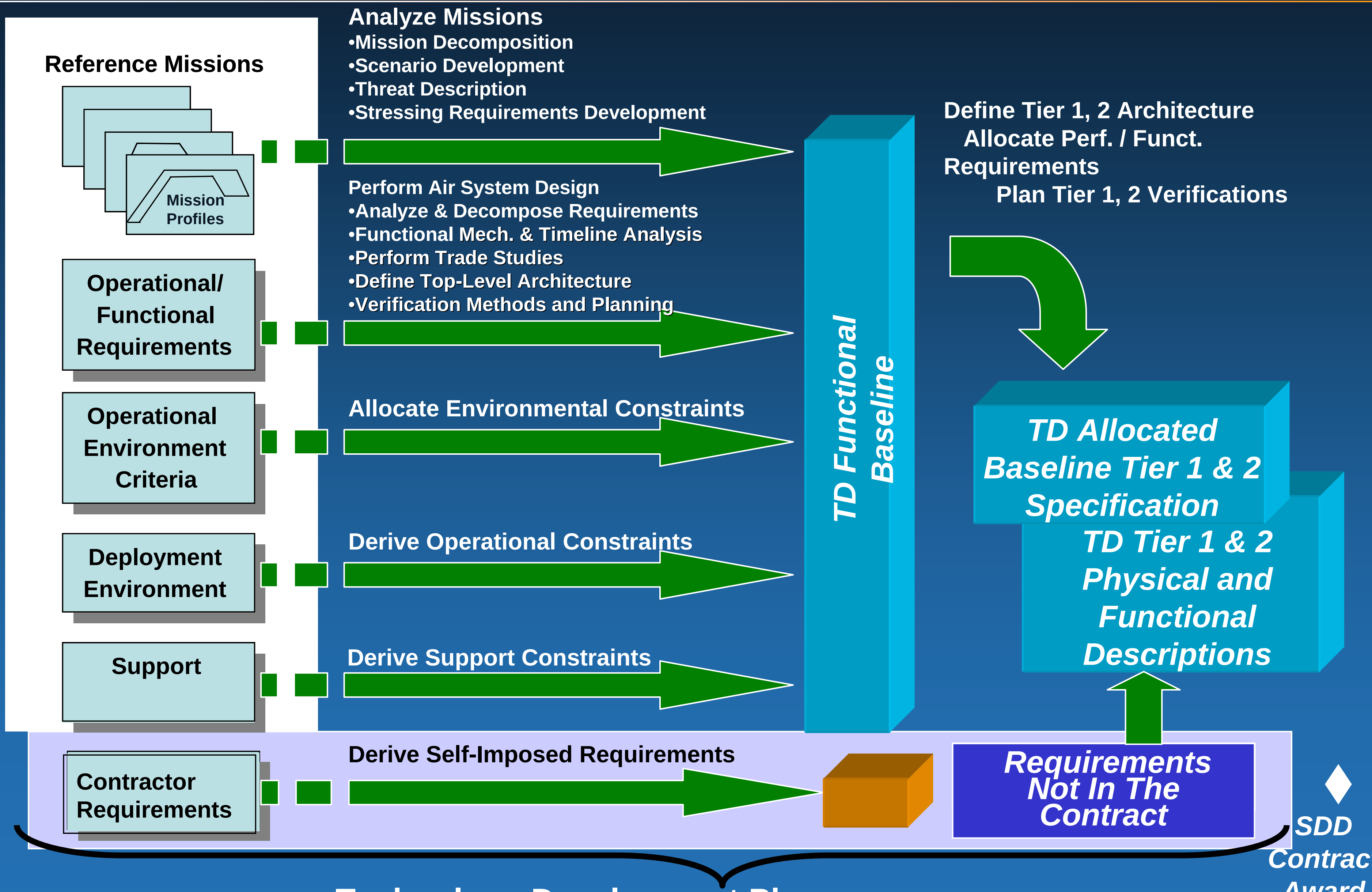


- Lower – level details expanded for program execution
- Program Technical Plan & Program Work Products Standard

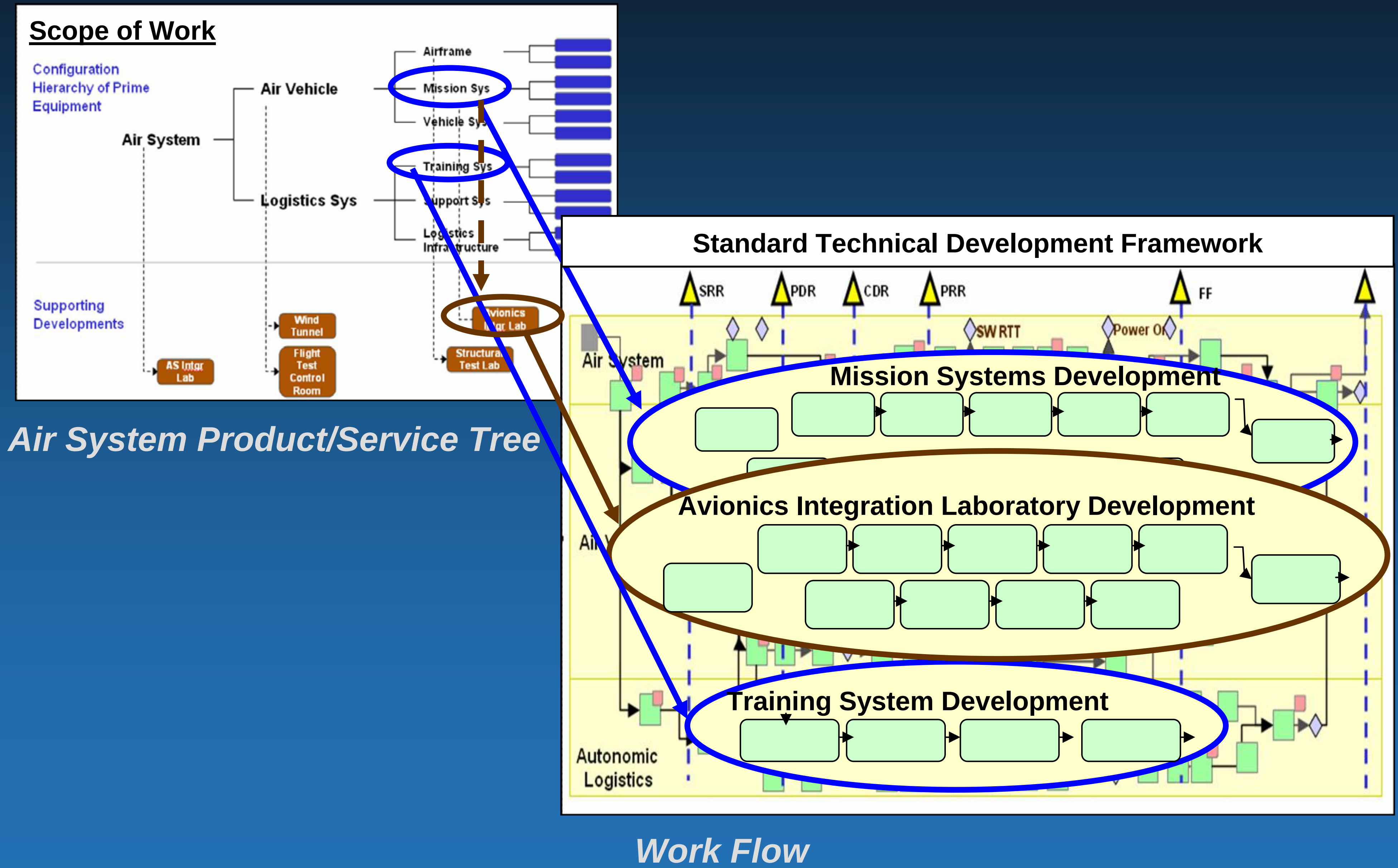


- Technical data management function
- Gatekeeper role
- An independent source of performance metrics
- Data dissemination controls

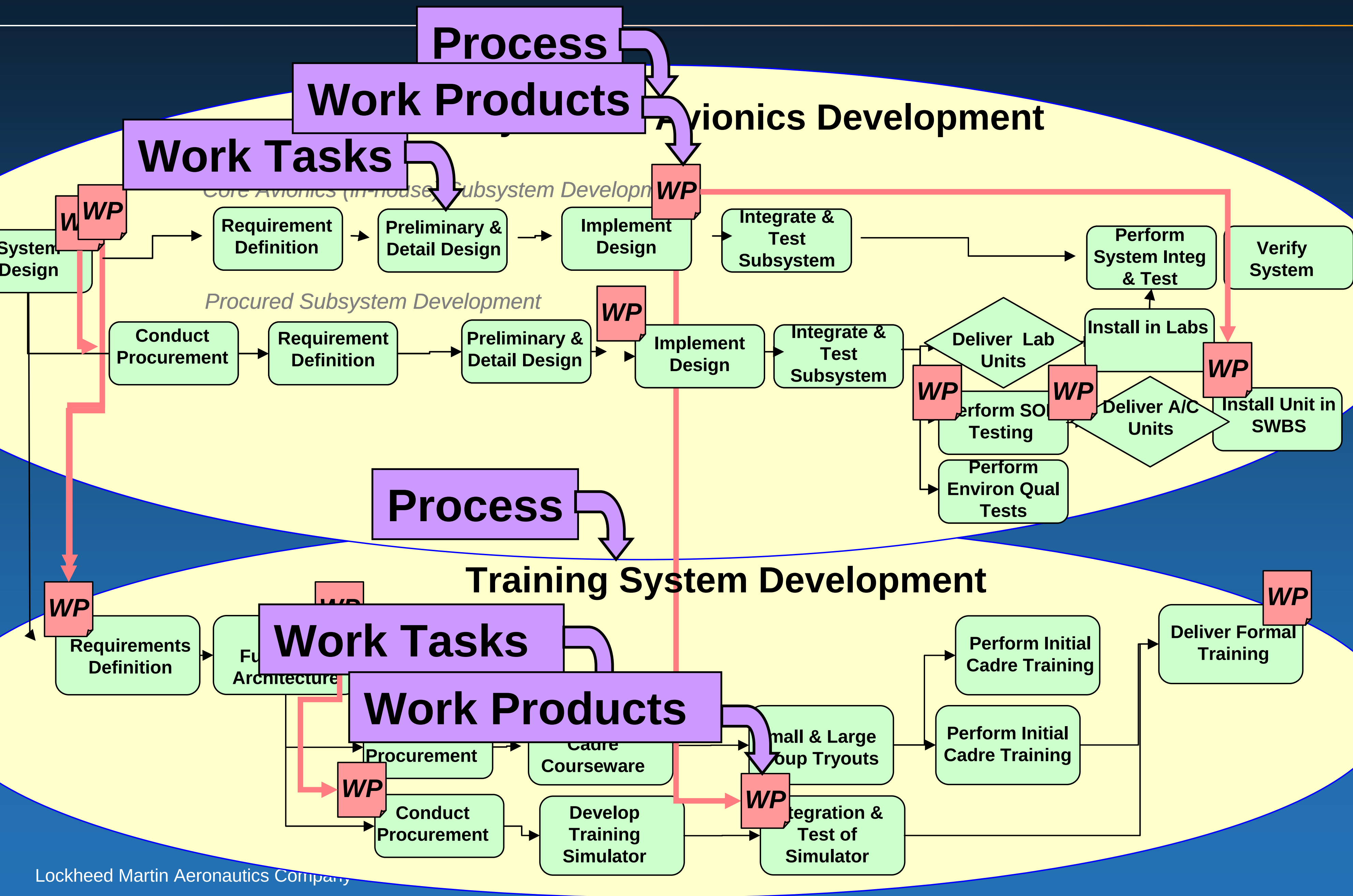
Air System Design – Late TD Phase



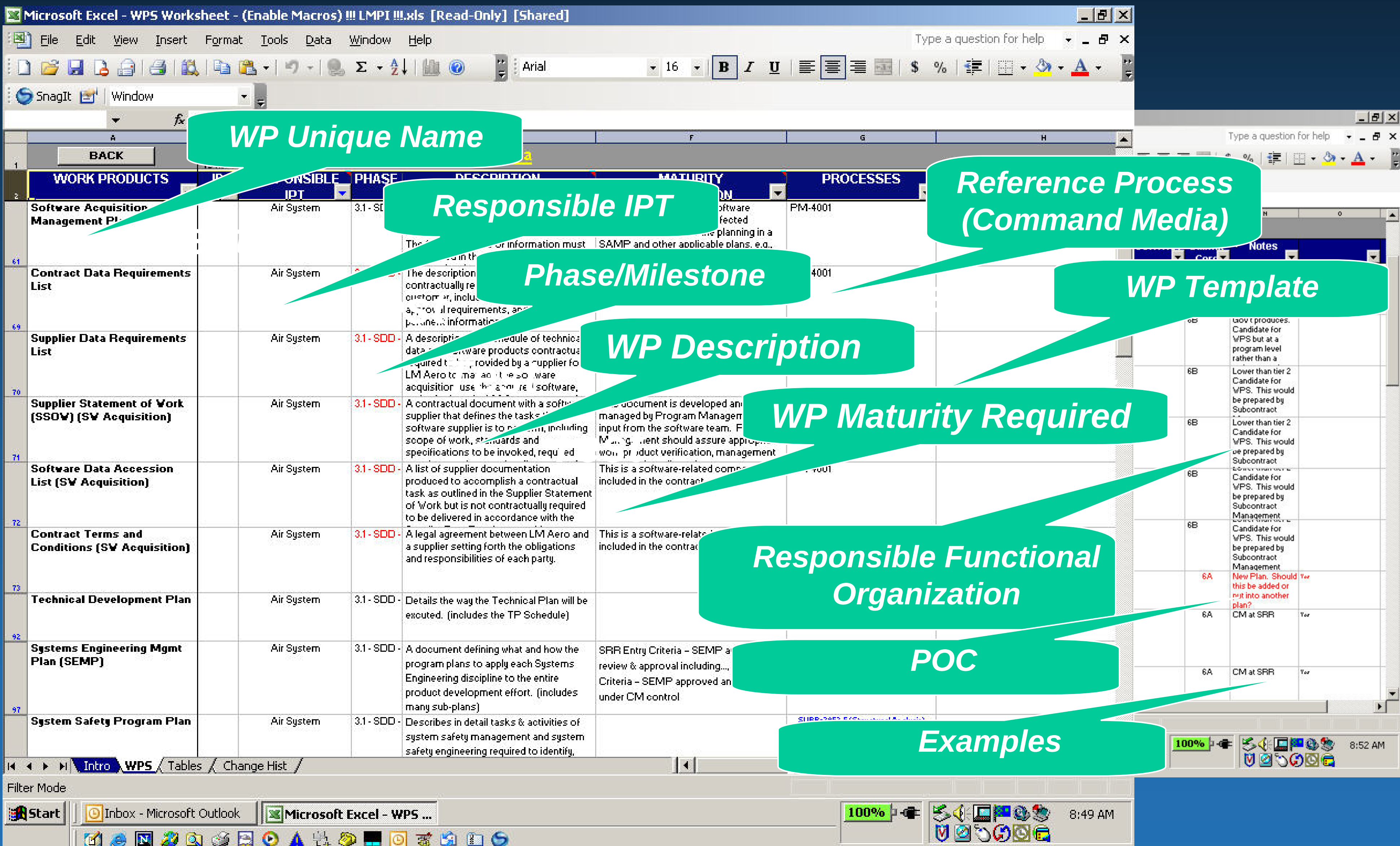
A Functional Execution Model Establishes Effort Scope



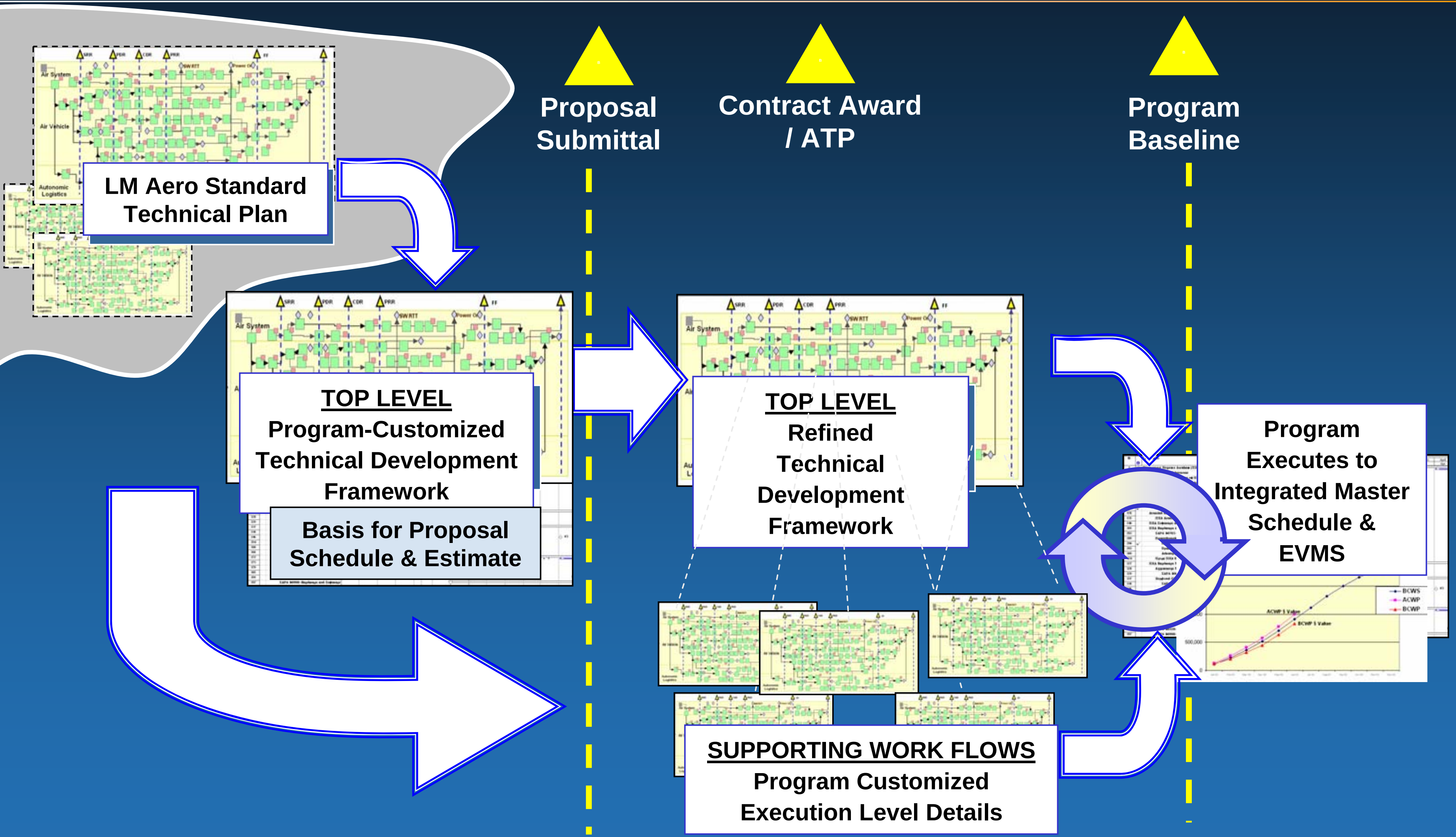
Work Flow Captures Tasks, Sequence, and Work Products



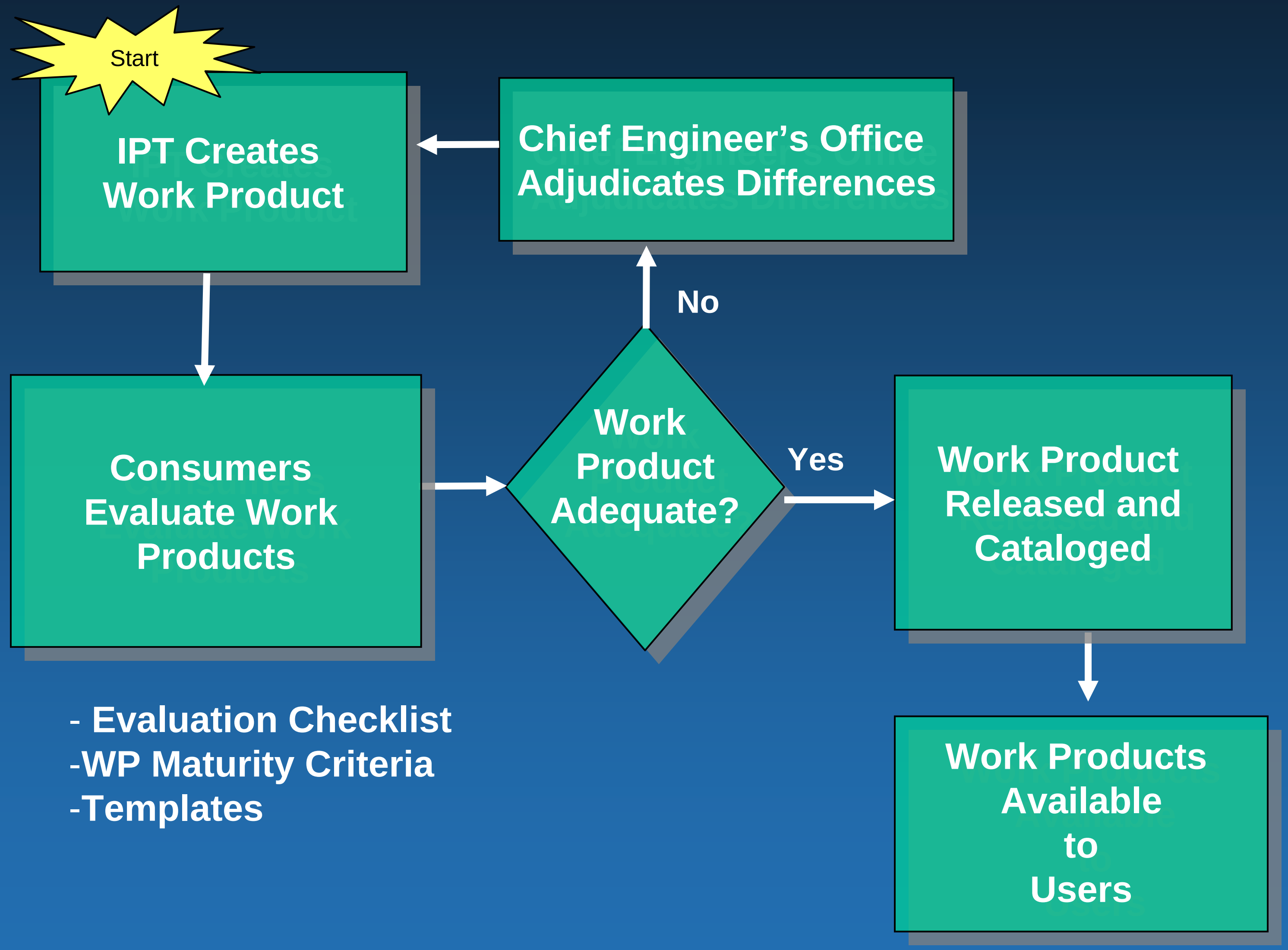
Valuable Information to Provide with Every Standard Work Product



Standard Plan Provides Sound Basis for Program Starting in Proposal Phase



Technical Integrity in the Release Process



- Evaluation Checklist
-WP Maturity Criteria
-Templates

LM Aero Approach to Systemic Development Issues Conclusions

- **In Order to Remedy Many of the Problems with Development Programs, the Necessary Top Level Design and Planning Must be Done Before M/S B.**

- **In Order to Function with Tomorrow's Workforce in Tomorrow's Development Environment, Our Industry Should Take a Lesson from the Commercial World and Make Our Development Business More Turn Key.**
  - ***Standard Planning Templates***
  - ***Standard Processes That Produce Standard Products.***
  - ***Command Media That Define The Best Practice for Generating the Work Product***

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SMU – EMIS

Systems Engineering Program

Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems

Michael Harper

Project Engineer, I2W SE

SPAWAR Systems Center Charleston

Dr. Jerrell Stracener

Systems Engineering Program Director

Southern Methodist University

Improving operational effectiveness through C4ISR common integrated solutions

Purpose

Define the framework for an investigation to improve concept development of new-start and reengineering of complex defense systems and systems of systems.

Formulate Systems Engineering approaches through systemic analyses to provide feedback into future policy, guidance, education, and training updates for Concept Development environment, methodology, tools and skills to increasing effectiveness of SE in Concept Development.

Current Environment

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Increasing System Complexity (SoS)

- –Network centric and extension of system applications are driving more integration
- –Functional and physical interfaces expanding in number and complexity
- –New approaches to testing balanced with modeling and simulation must match new system of systems requirements

Experienced but Aging Work Force

Not sufficient Systems Engineering education, research and training resources to meet needs

Issue	Single System	System of System
Constituents	All known and visible	Changing, potentially unknown May not know is part of SoS
Purpose	Predetermined by system owner and conveyed to constituents	Continuously evolving, cooperatively determined, may or may not be known by systems participating in SoS
Control	Hierarchically structured	No control in SoS
Requirements	Defined and managed by System Owner	Often required to anticipate how system will be used
Ownership	Pieces developed are owned, maintained, and evolved by owner	Independently owned, developed, maintained, and evolved
Boundaries	Closed with clearly defined boundaries	In general, unbounded and part of a larger SoS
Visibility	All aspects seen, understood and controlled	Components and process aspects beyond control and visibility of developers, users, and owners

Smith, et al. SEI, 2006

Objective

- Develop a framework for identification of overlap, gaps and needs based on current and evolving DoD program acquisition policies and regulations
  - **Identified to determine improvement candidates**
- Specific focus directed at earlier "real" consideration of critical elements
  - **Reliability, Availability, Logistics (sustainment), Security and Disaster Tolerance**
- Directed at Aerospace / Defense / Security sectors

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Research Framework

•Motivation

•Needs

Vision

Goal

Objectives

Concept Exploration

Report

•Preferred Concept

•Process Documentation

•Analyses and Trade

•Reference Material

Executive Review and Refinement

• Boundaries

• Constraints

• Ground Rules and Assumptions

System Development Plan

• Long Range Strategic Framework

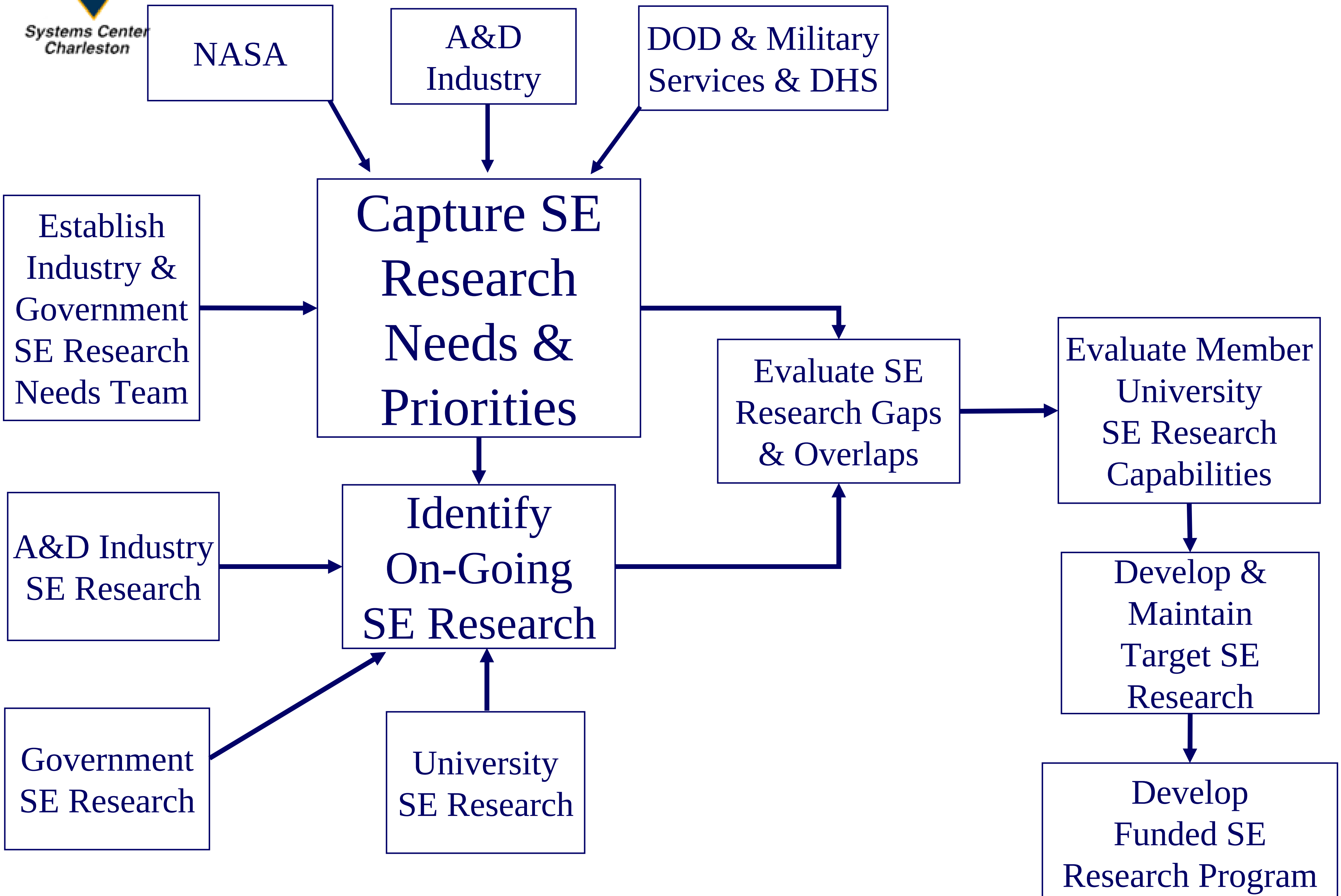
• Product (Services) Development Plan

Methodology

Specific tasks necessary to evolve the framework

- Industry and government needs capture and assessment
- Identification and analysis of capabilities
- Analysis for gaps and overlaps with respect to needs
- Explore and define alternatives for needs response
- Evaluate and refine alternates to evolve preferred concept
- Strawman research framework development plan

A&D SE Research Process Concept



Critical Elements of Defense Engineering of Complex Systems

Critical elements identified for engineering of complex defense systems

– SoS Critical Element Reliability and Availability
– SoS Disaster Tolerance
– SoS Security
– Culture and Infrastructure

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Critical Element SoS Reliability and Availability

Metrics

- Mean Time between SoS maintenance and support
- Expected Failure free SoS operation time: MTBF
- SoS Mission Success Probability
- Probability of SoS being ready for use

Features that determine SoS

- Likelihood of being ready for use / mission success probability
- Life cycle cost in terms of product and customer support

Consequences not considering R&A as critical SoS elements

Critical Element SoS Disaster Tolerance

SoS Disaster

- Catastrophic Failure in System A can Result due to Missing Requirement in System B
- Disaster Tolerant Driven Requirements Definition MUST OCCUR at SoS Level

Enormous SoS Complexity Necessitates

- High-level, Manageable SoS Model with “What-if” Analysis Capability (SysML?)
- Simple, Robust Injection of Failure Models in Component SoS Systems
- Capability to Ensure DT in Presence of Failure Model

Critical Element SoS Security

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- Ensuring access and functional security difficult for single component
- Exponentially more difficult for SoS
  - Internet-based access architecture
  - Shortened development and deployment cycles
  - Integration complexity
  - Costly and time-consuming
- Model-Based Security Testing
- SysML models for security testing
  - Attack models
  - Verification vs. validation
  - Integration security?

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Critical Element
Culture and Infrastructure

Characteristics of DoD and Corporate Culture

- Identify cultural norms of enterprises (DoD and contractors)
- Understanding cultural norms wrt senior management decision making
- Influencing the growth of enterprise cultures

Leveraging DoD/ Contractor Infrastructures and IP

- Understanding competing DoD & contractor needs
- Leveraging/reuse of prior design to shorten development timelines (set-based concurrent engineering)

Role of Systems Engineering in Enterprise

- Identification of SE role with respect to PM and senior management

Role of Initiatives

- CMMI (Effects on Corporate Culture)
- Lean, Six Sigma and Collective System Design

Implementation

Advancing SE Technology

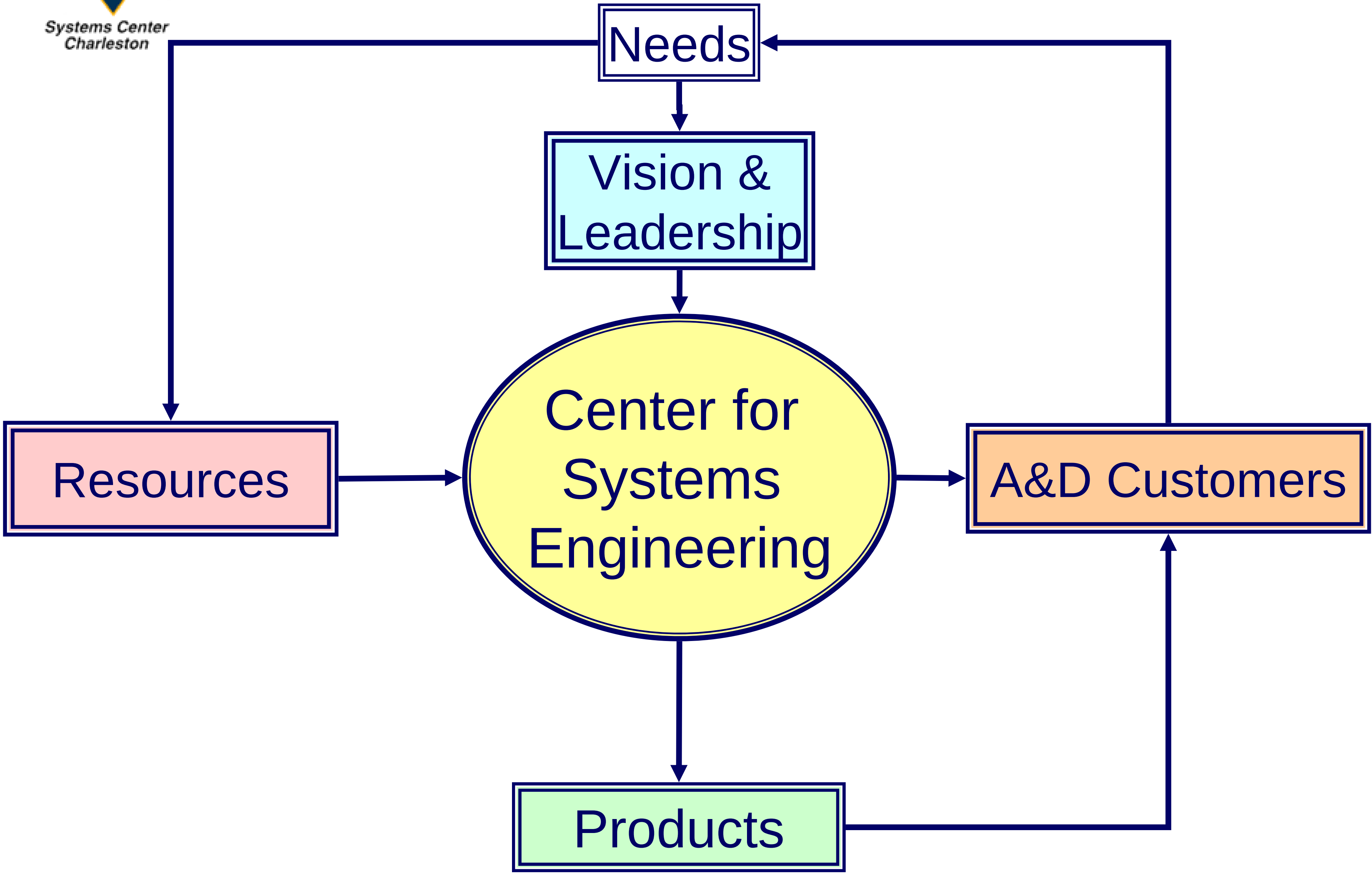
SE Think Tank

Center for Systems Engineering

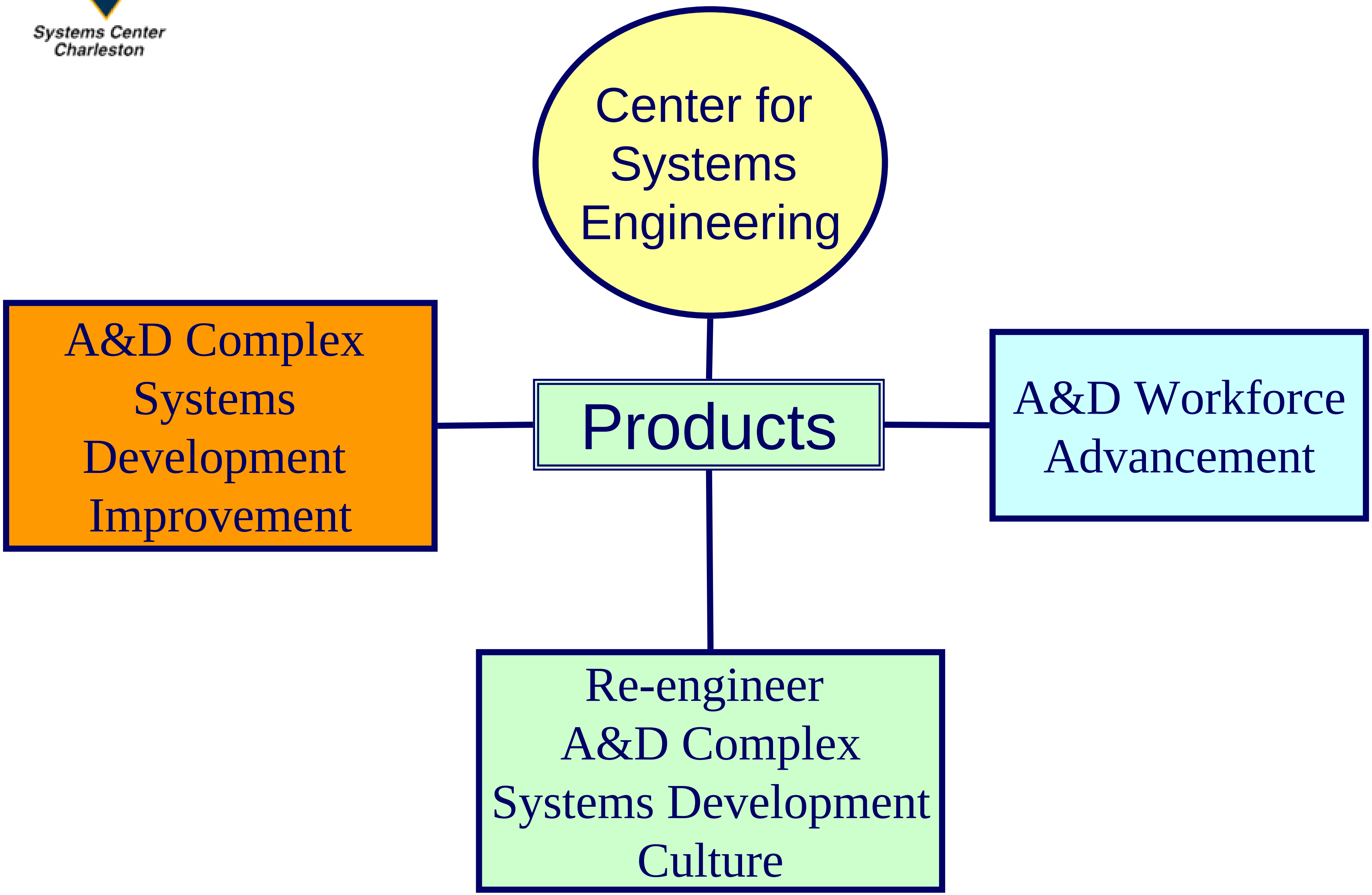
Engineering Work Force Advancement

An Industry-Government-University Partnership to Improve Development of Complex A&D Systems

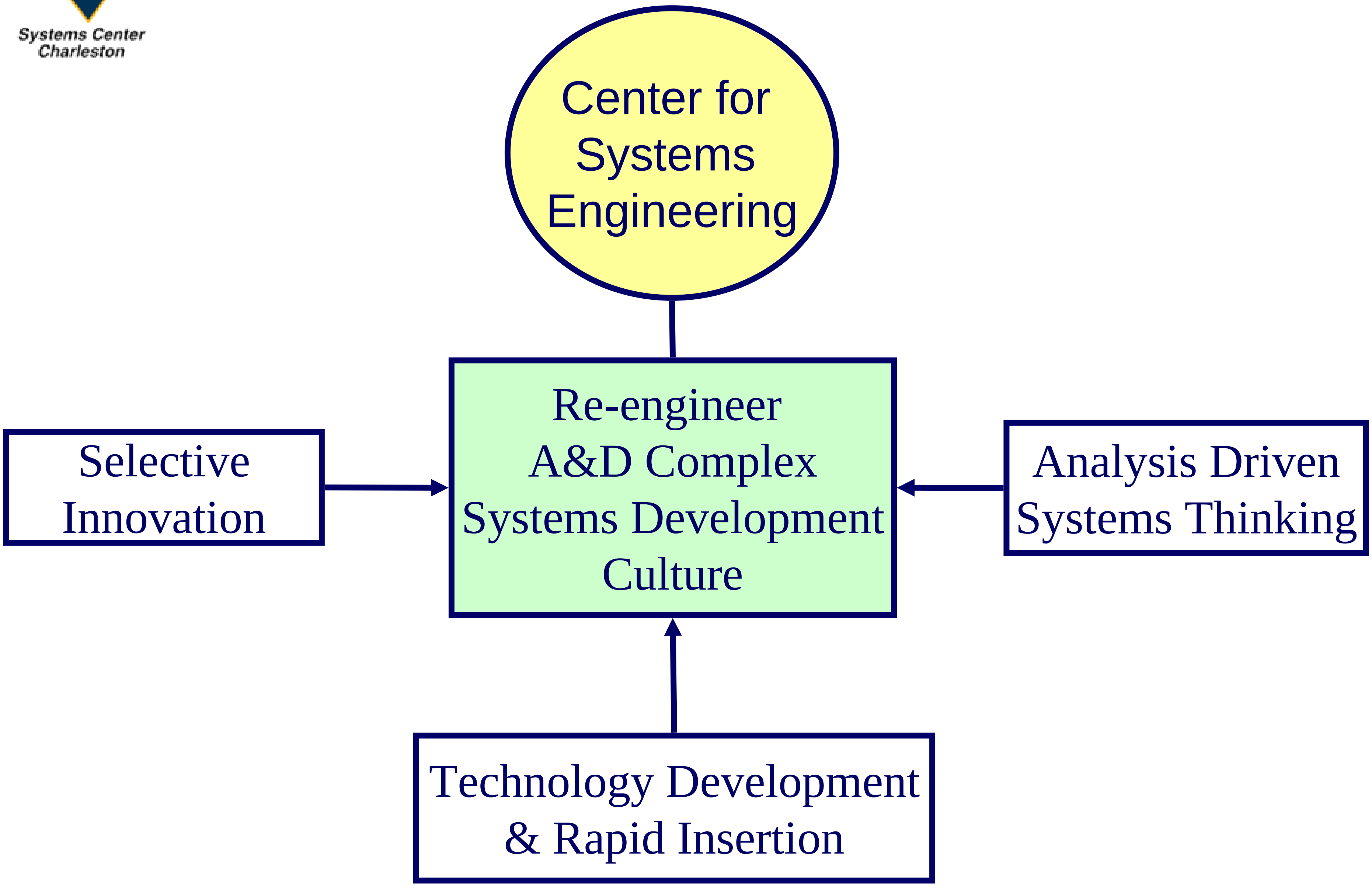
Functional Concept



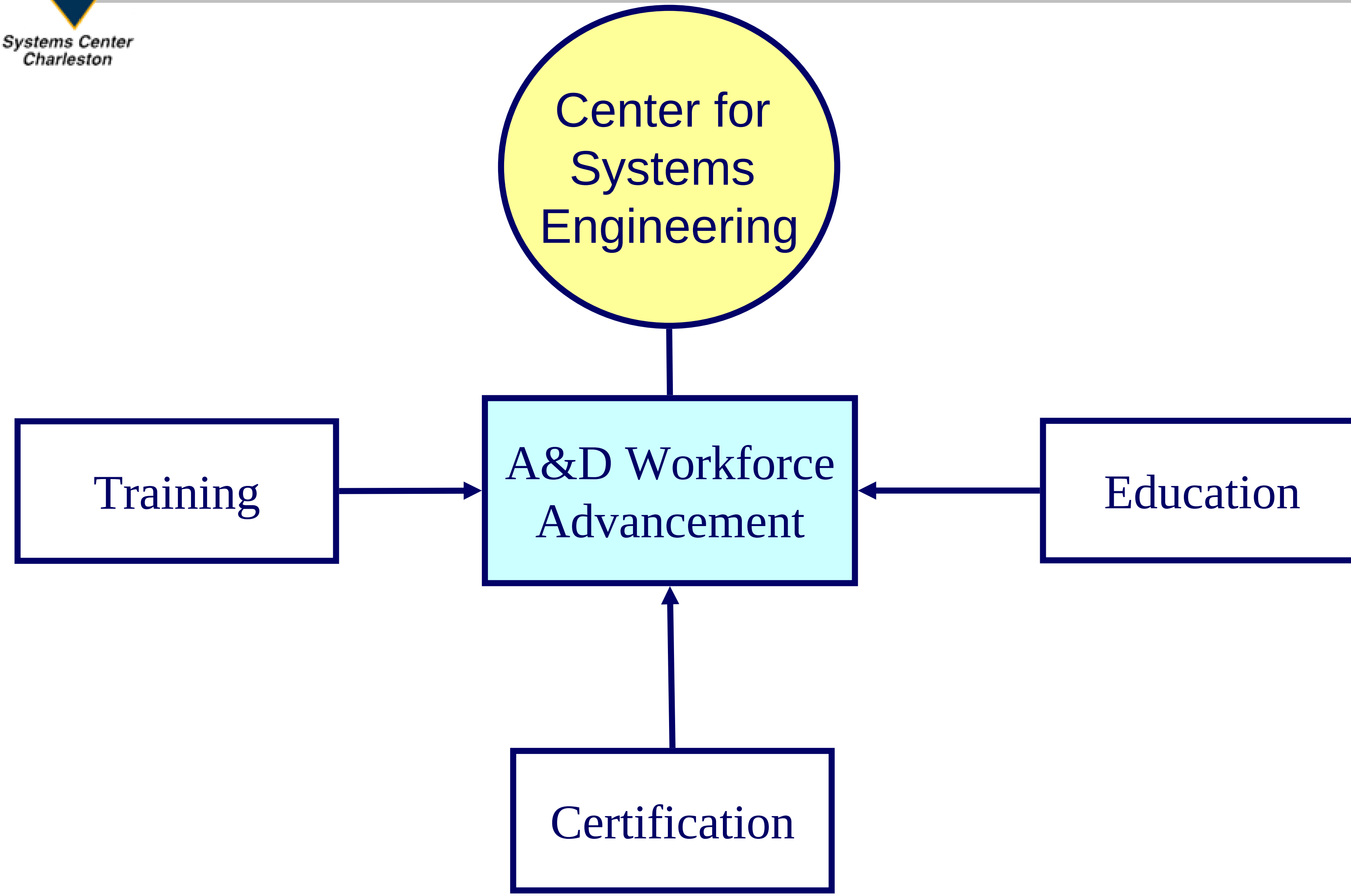
Functional Concept



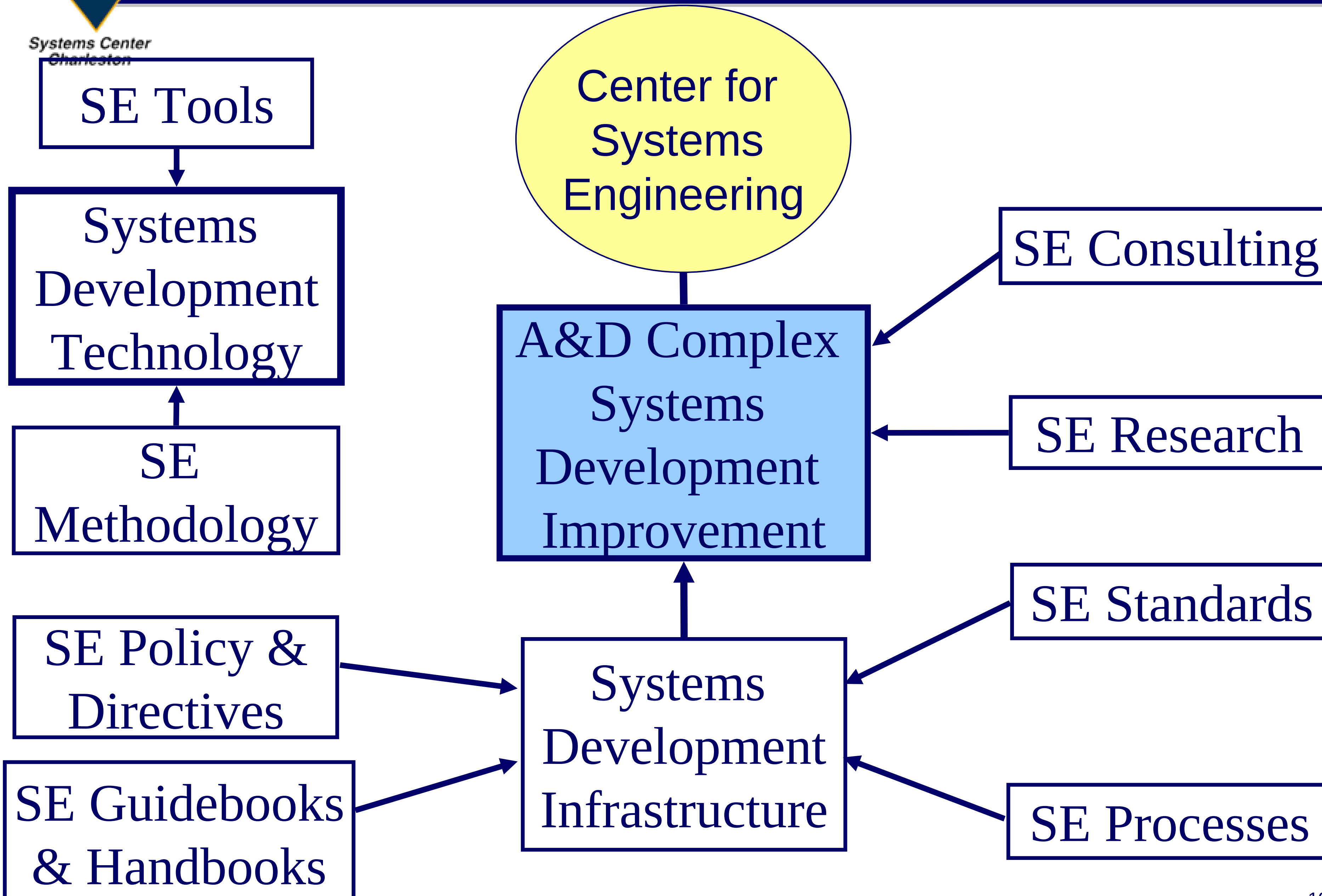
Functional Concept



Functional Concept



Complex Systems Development



Center for SE – Overview Concept

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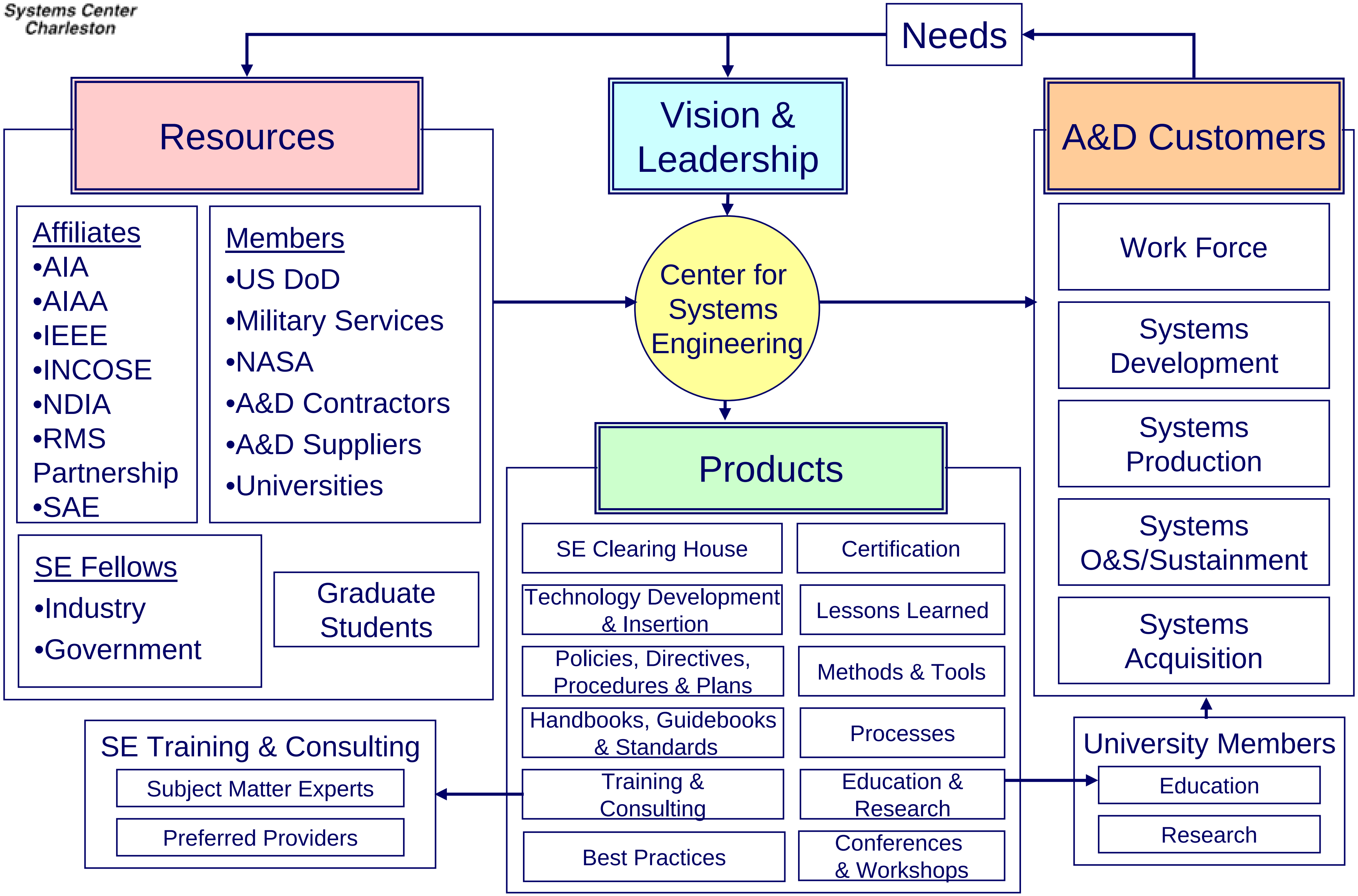

Summary

- Vision, Goal and Plan Formulated
- Research Initiatives Evolving
- Key Meetings Planned
- Team being Expanded – Task Driven

Challenge is to focus resources on Concept Exploration & Definition – Not Detailed Design

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SMU – EMIS
Systems Engineering Program

Thank you!

Questions?

Application of
Risk Management Practices to
NNSA Tritium Readiness Subprogram

National Defense Industrial Association
10th Annual
Systems Engineering Conference
October 22-25, 2007

Sham K. Shete'
Srini Venkatesh
Systems Engineering
Savannah River Site
Washington Savannah River Co.
Aiken, South Carolina

National Nuclear Security Administration

- A separately organized agency within the U.S. Department of Energy
- Established by Congress in 2000
- Responsible for enhancing national security through the military application of nuclear science
- Maintains and enhances the safety, security, reliability and performance of the U.S. nuclear weapons stockpile without nuclear testing
- Works to reduce global danger from weapons of mass destruction
- Provides the U.S. Navy with safe and effective nuclear propulsion
- Responds to nuclear and radiological emergencies in the United States and abroad

NNSA Tritium Readiness Subprogram

- One of NNSA’s missions is to provide tritium to the US nuclear stockpile.
- Tritium Readiness Subprogram is to establish a system that can ensure that the inventory is maintained by producing new tritium to replace that tritium lost to radioactive decay and consumption.
- The Tritium Production System of this subprogram will produce tritium by irradiating the NNSA-designed Tritium Producing Burnable Absorber Rods (TPBARs) in reactors operated by the Tennessee Valley Authority (TVA), an independent government agency.
- These TPBARs will be manufactured commercially.
- After irradiation, the radioactive TPBARs will be removed from the reactors and transported to a new Tritium Extraction Facility (TEF) at the Savannah River Site (SRS).
- There the tritium will be removed from the rods using a special vacuum-thermal process.

Scope of TR Subprogram Risk Assessment

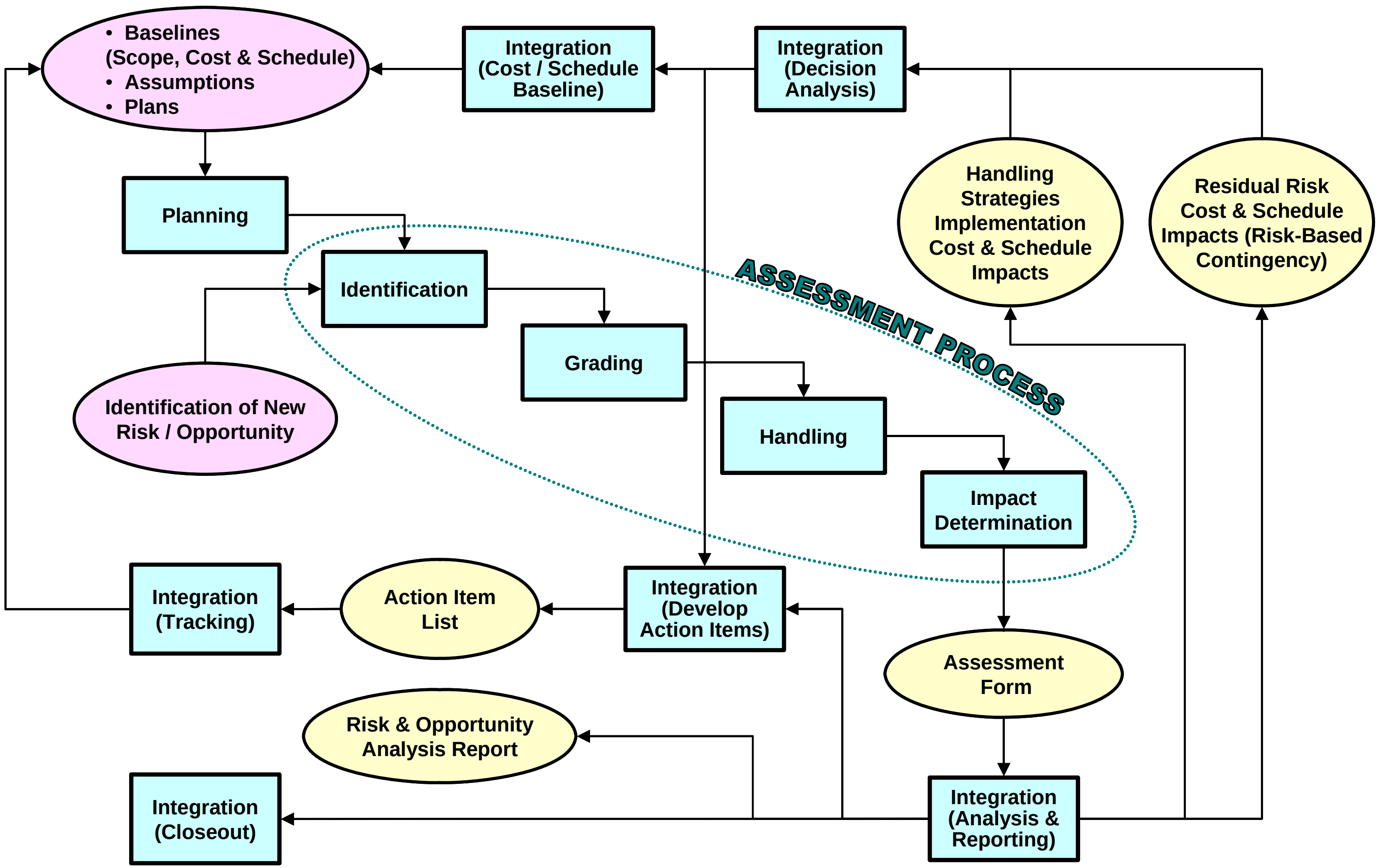
•An *Assessment* of NNSA Tritium Readiness Subprogram risks was conducted as part of the Risk Management Process adopted by the NNSA.

•The *goal* of this overall assessment was to identify risks to the Subprogram and to develop handling strategies with specific action items that could be scheduled and tracked to completion in order to minimize program failures.

•The issues and assumptions developed during the assessment planning stage were considered during several meetings by a team comprised of individuals representing

- Pacific Northwest National Laboratory (PNNL),
- WesDyne,
- Kansas City Plant (KCP),
- NNSA,
- NAC,
- Tennessee Valley Authority (TVA), and
- Savannah River Site (SRS) in identifying risks

RISK ASSESSMENT PROCESS



Risk Grading Guidelines

Likelihood (L)	Criteria
Non-Credible	Determined (through formal probability calculations) to have a probability of occurrence of ≤ 10^{-6} (or other non-credible probability defined for the activity)
Very Unlikely	•Estimated recurrence interval > 20 years (or perceived life of program); or •Will not likely occur anytime in the life cycle of the Tritium Readiness Subprogram; or •Estimated recurrence frequency < 1 (i.e., event not expected to recur); or •0% < Likelihood of single event occurrence < 15%.
Unlikely	•Will not likely occur in the life cycle of the Tritium Readiness Subprogram; or •10 years < Estimated recurrence interval ≤ 20 years; or •1 ≤ Estimated recurrence frequency < 2 (i.e., event expected to recur but not more than once); or •15% ≤ Likelihood of single event occurrence < 45%.
Likely	•May occur sometime during the life cycle of the Tritium Readiness Subprogram; or •5 years < Estimated recurrence interval ≤ 10 years; or •2 ≤ Estimated recurrence frequency < 5 (i.e., event expected to recur from 2 to 4 times); or •45% ≤ Likelihood of single event occurrence < 75%.
Likely Likely	•Will likely occur sometime during the life cycle of the Tritium Readiness Subprogram; or •Estimated recurrence interval ≤ 5 years; or •Estimated recurrence frequency ≥ 5 (i.e., event expected to recur more than five times); or •75% ≤ Likelihood of single event occurrence < 100%.

Risk Grading Guidelines

Consequence (C)	Criteria
Negligible	•Minimal consequences; unimportant. •Some potential transfer of money (≤ $500K), but budget estimates not exceeded. Negligible impact on program; minimal potential for schedule change; compensated by available schedule float.
Marginal	•Small reduction in Tritium Readiness Subprogram technical performance. •Moderate threat to Tritium Readiness Subprogram mission, environment, or people; may require minor facility redesign or repair, minor environmental remediation, or first aid/minor medical intervention. •Cost estimates marginally exceed planned budget (> $500K, but ≤ $1M). •Minor slip in schedule (anything less than 3 months) with some potential adjustment to milestones required.
Significant	•Significant degradation in Tritium Readiness Subprogram technical performance. •Significant threat to Tritium Readiness Subprogram mission, environment, or people; requires some facility redesign or repair, significant environmental remediation, or causes injury requiring medical treatment. •Cost estimates significantly exceed planned budget (> $1M, but ≤ $5M). •Significant slip in schedule (3 months to less than 12 months) with resulting milestones changes that may affect Tritium Readiness Subprogram mission.
Critical	•Technical goals of Tritium Readiness Subprogram cannot be achieved. •Serious threat to Tritium Readiness Subprogram mission, environment, or people; possibly completing only portions of the mission or requiring major facility redesign or rebuilding, extensive environmental remediation, or intensive medical care for life-threatening injury. •Cost estimates seriously exceed planned budget (> $5M, but ≤ $10M). •Excessive schedule slip (12 months to ≤ 18 months) unacceptably affecting overall mission of Tritium Readiness Subprogram objectives, etc.
Crisis	•Tritium Readiness Subprogram cannot be completed. •Cost estimates unacceptably exceed planned budget (> $10M). •Catastrophic threat to program mission; possibly causing loss of mission. •Schedule slips > 18 months.

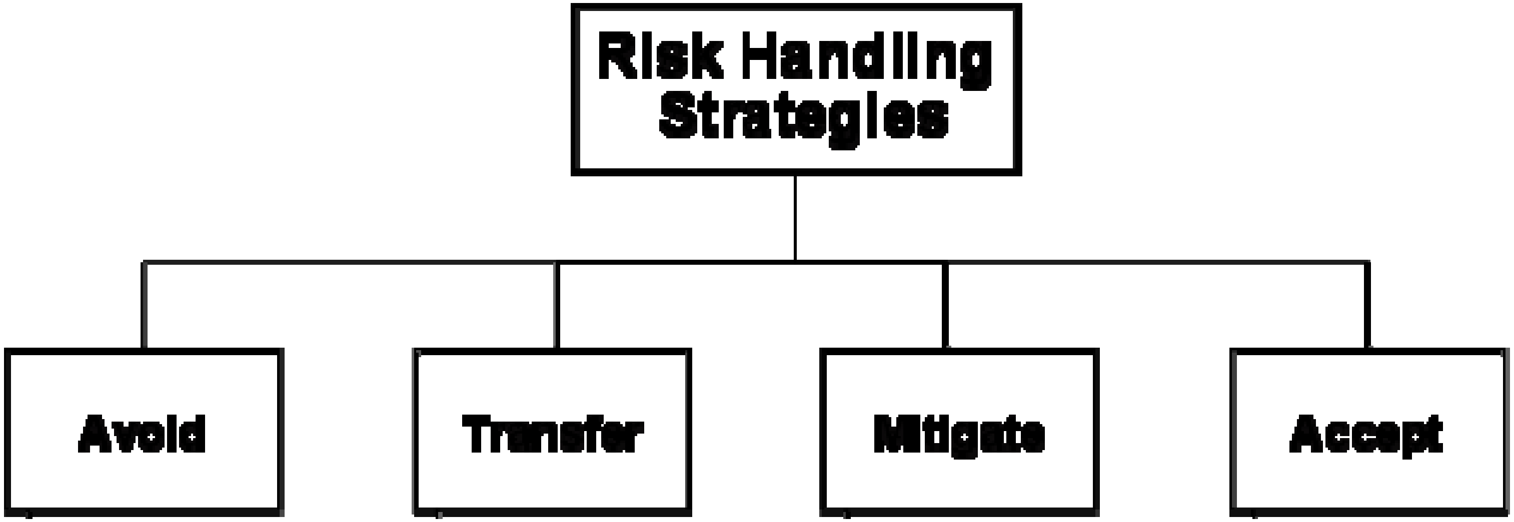
Risk Grading Matrix

Likelihood (L)	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	Moderate	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Moderate	High
*Non-Credible	Low				

Consequence (C)

* Normally limited to assessing residual risks with Crisis consequences

Risk Handling Strategies



TR Subprogram Risk Assessment Steps

- Identified total 94 risks events.
- Dispositioned 41 events as ‘combined with others’, ‘deleted’, and ‘resolved’
- Performed Initial Assessment of 50 out of 53 active risk events
- Documented Assessment in the Risk Database/Risk Form
- Identified Risk Handling Strategies and Action Items
- Performed “Post-handling” Assessment of residual risks
- Performed a cost contingency analysis using “Crystal Ball” software
- Performed Risk Ranking using mean cost contingency
- Tracked Risk Handling Strategy Action Items
- Reported Risk Status during Quarterly Program Review meetings
- Re-assessed TR Subprogram Risks annually

Risk Assessment Form

ID Number: Revision: Last Date Evaluated: Status:

Event Title:			
Type: Risk		Category:	
Assess. Element:		Title:	
Responsible Org:		Contact:	Date Identified:
Statement of Event:			
Likelihood:		Basis:	
Consequence / Benefit:		Basis:	
Most Significant Cost Impact ($k):		Most Significant Schedule Impact (Mos):	
Level:		Event Trigger:	
Handling Strategy:		Description:	
Handling Strategy Action Items:			
HS Implementation Cost ($K):		Basis:	
HS Implementation Schedule (Mos):		Basis:	
Other Handling Strategies:			
Statement of Residual Risk:			
Residual Likelihood:		Basis:	
Residual Consequence:		Basis:	
Residual Risk Level:	Moderate		Residual Impact Basis:
Residual Cost Impact ($K):	Best Case	Most Likely	Worst Case
Residual Schedule Impact (Mos):			
Impacted Scope of Work:			
Evaluation Comments:			
Event Comments:			

Risk Handling Strategies & Their Impact

Avoid	4
Transfer	0
Mitigate	31
Accept	13

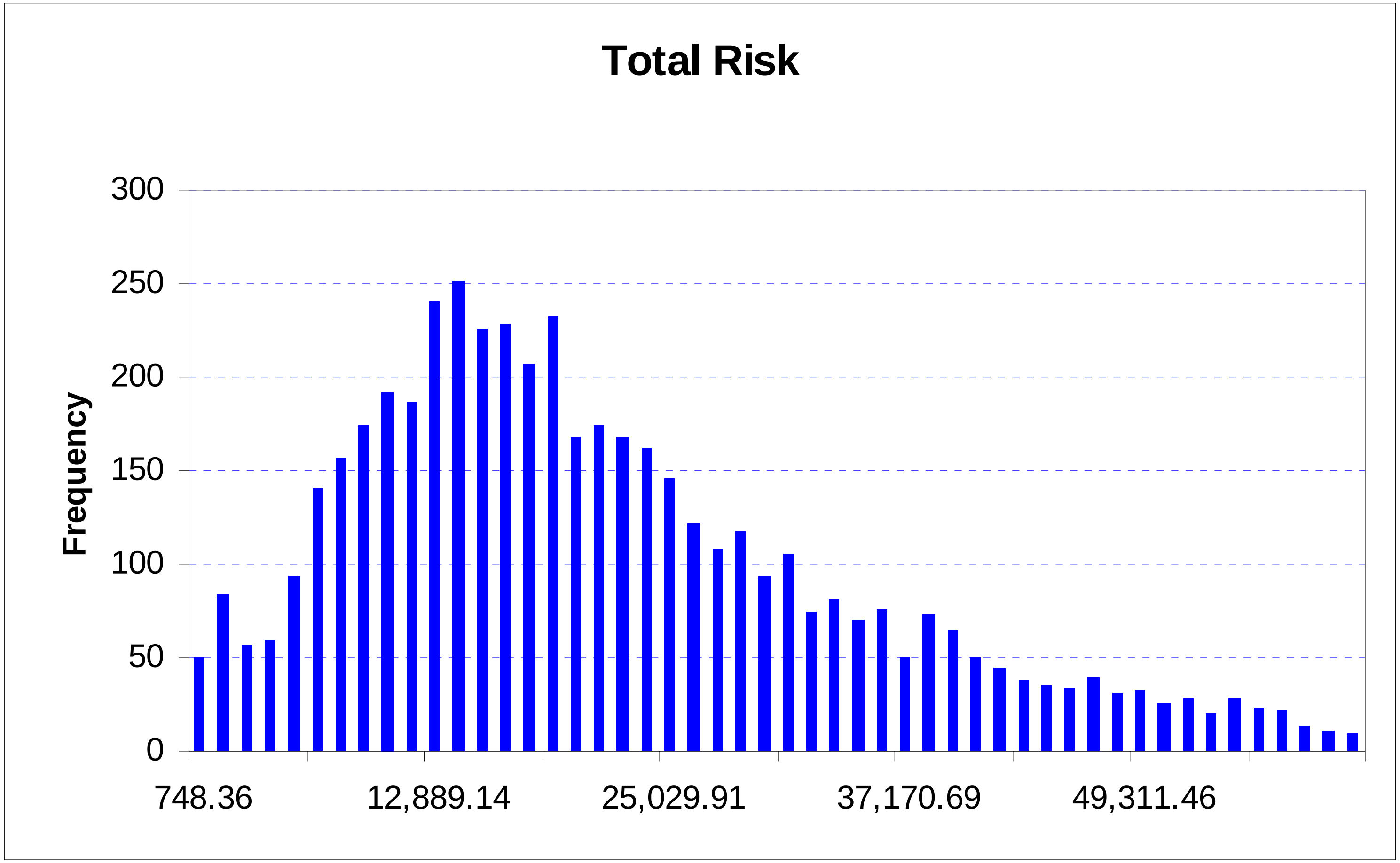
Risk Level	Initial	Residual
High	21	7
Moderate	22	16
Low	7	20

Risk Ranking & Cost Contingency

Ranking	Risk ID	Title	Mean Contingency $K	Mean-Total Contingency $K	%
1	40	Equipment Design Change	6,181.11	22,284	27.74
2	38	Impacts of Costing Factors Outside Program's Control	3,329.46	22,284	14.94
3	77	Yield Impacts Production Success	2,259.09	22,284	10.14
4	8	Loss of Vendor A as a Long-Term Supplier	2,162.99	22,284	9.71
5	33	Equipment Consolidation Process Design	1,746.17	22,284	7.84
6	4	Loss of Vendor B as a Long-Term Supplier	1,523.00	22,284	6.83
7	23	Loss of Testing Capability	800.46	22,284	3.59
8	48	Unable to Reduce Uncertainties to Meet Program Needs	520.48	22,284	2.34
9	41	Equipment Performance impact	506.85	22,284	2.27
10	92	Excessive impurities in Materials	493.01	22,284	2.21

Total Cost Contingency	
Percentiles	**Contingency ($K)**
60%	**22,470**
80%	**32,511**

Cumulative Residual Risk-Based Cost Contingency



Benefits of Risk Management Process

- Quarterly review and update of the Risk Management Database
- Risk status and handling strategy action item tracking mechanism
- Generation of risk handling strategy cost & schedule
- Generation of a risk-based cost contingency estimate

Identifying Acquisition Patterns of Failure Using Systems Archetypes

Finding the Root Causes of Acquisition Problems

Bill Novak
Dr. Linda Levine
October 24, 2007

Purpose of this Presentation

To show how Systems Thinking and the Systems Archetypes can help to avoid common counter-productive behaviors in software acquisition and development programs

Agenda

- Systems Thinking
- Feedback Loops and Causal Loop Diagrams
- Selected Systems Archetypes
  - Fixes that Fail
  - Shifting the Burden
  - Limits to Growth
- Selected Software Acquisition and Development Archetypes
  - Sacrificing Quality
  - Firefighting
  - The Bow Wave Effect
- Seeing the Bigger Picture and Breaking the Pattern

Why is Software-Intensive Acquisition Hard?

Complex interactions between PMO, contractors, sponsors, and users

Limited visibility into progress and status—hard to comprehend

Significant delays exist between applying changes and seeing results

Unpredictable and unmanageable progress and results

Uncontrolled escalation of situations despite best management efforts

Linear partitioning ("Divide and conquer") isn't working well

Exponential growth of interactions as size grows linearly

Acquisition Programs are Dynamic Systems

Complex Interactions: Interactions between acquisition stakeholders are *non-linear*

Non-linear Behavior: Non-linear behavior defies traditional mathematical analysis because of the presence of feedback

Non-deterministic: Complex systems are not deterministic

Sensitivity to Initial Conditions: Results may vary greatly due to seemingly insignificant differences in the starting point(s)

Organizational: Key issues in software acquisition are management and organizational—*not* technical

Partitioning: Not possible with complex interactions between components

What is Systems Thinking?

Systems Thinking developed from work done by Jay W. Forrester at MIT while modelling electrical feedback effects

- Also exists in economic, political, business, and organizational behaviors

Uses feedback loops to analyze common system structures that either spin out of control, or regulate themselves

Helps identify a system's underlying structure, and what *actions* will produce which *results* (and *when*)

Systems Thinking teaches us that:

- *System behavior is greater than the sum of component behaviors*
- "Quick fix" solutions usually have side-effects that make things worse
- Improvement comes only from changing the underlying system structure

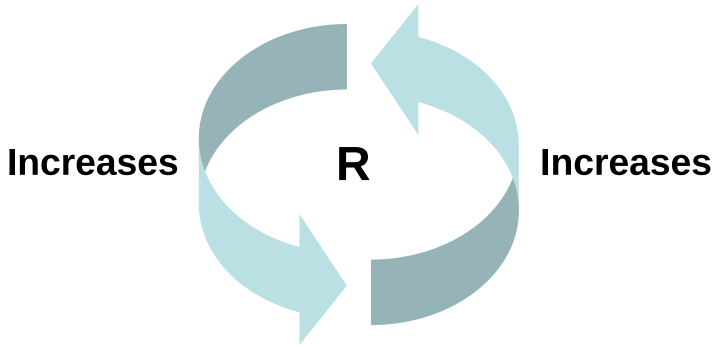
Causal Loop Diagrams (CLDs)

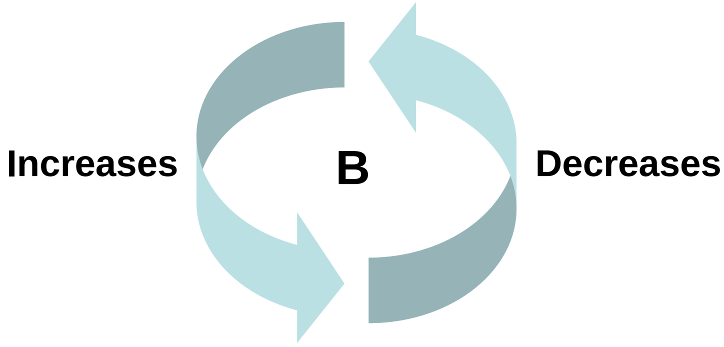
Depict qualitative "*influencing*" relationships (increasing or decreasing) and time delays between key variables that describe the system

Show relationship direction by labelling them **S**ame (**+**) or **O**pposite (**-**) to indicate how one variable behaves based on the previous variable

Consist primarily of two types of feedback loops:

- **R**einforcing – Changes to variables *reinforce*, moving in one direction
- **B**alancing – Changes to variables *alternate*, achieving equilibrium





Time Delays

Much instability and unpredictability of systems is due to time delays

Time delays obscure the connections in cause-and-effect relationships

- Side-by-side causes and effects would be “smoking gun” evidence

People are inherently poor at controlling systems with substantial time delays between cause and effect

Examples:

- Over-steering a large ship that is slow to respond, so it weaves back and forth
- A thermostat controlling a low-BTU air conditioner that’s slow to cool, so the house temperature bounces between too hot and too cold
- Inability to determine which surface, handshake, sneeze, or cough resulted in an infection

What are the Systems Archetypes?

The Systems Archetypes depict the underlying structures of a set of dynamic behaviors that occur in organizations throughout the world

- Each causal loop diagram tells a familiar, recurring story
- Each describes the system structure that causes the dynamic

Archetypes are used to:

- Identify failure patterns as they develop (*recognition*)
- Single out root causes (*diagnosis*)
- Engage in “big picture” thinking (*avoid oversimplification*)
- Promote shared understanding of problems (*build consensus*)
- Find interventions to break out of ongoing dynamics (*recovery*)
- Avoid future counter-productive behaviors (*prevention*)

Systems Archetypes

Over 10 recurring "systems archetypes" have been identified, including:

Fixes that Fail

- A quick fix for a problem has immediate positive results, but its unforeseen long-term consequences worsen the problem.

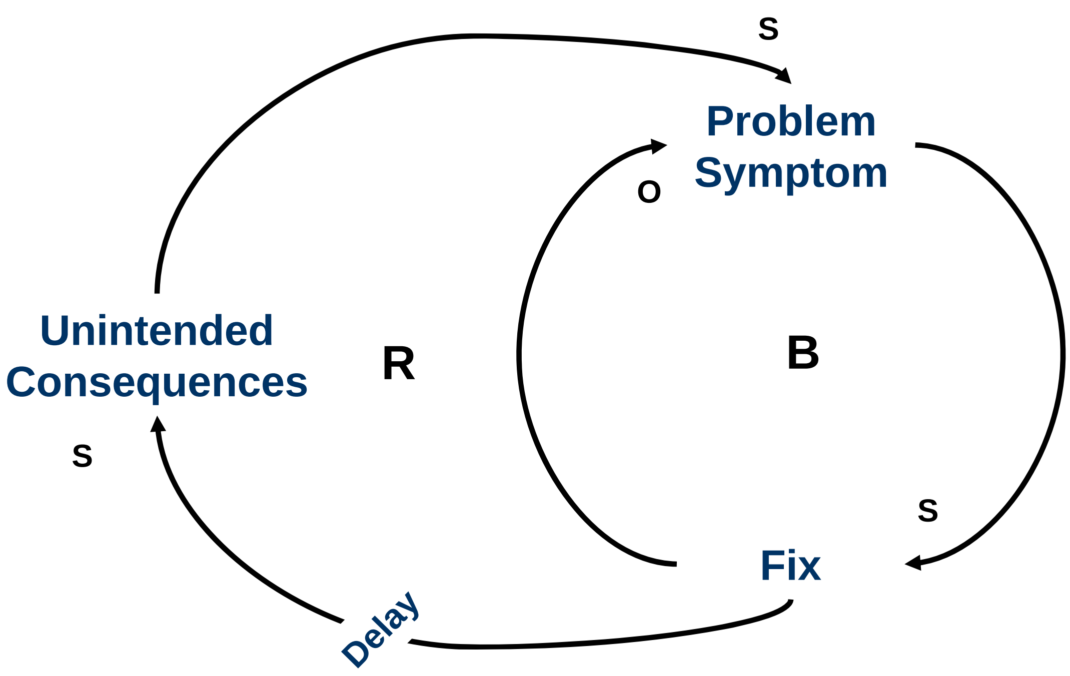
Shifting the Burden

- An expedient solution temporarily solves a problem, but its repeated use makes it harder to use the fundamental solution.

Limits to Growth

- Initially rapid growth slows because of an inherent capacity limit in the system that worsens with growth.

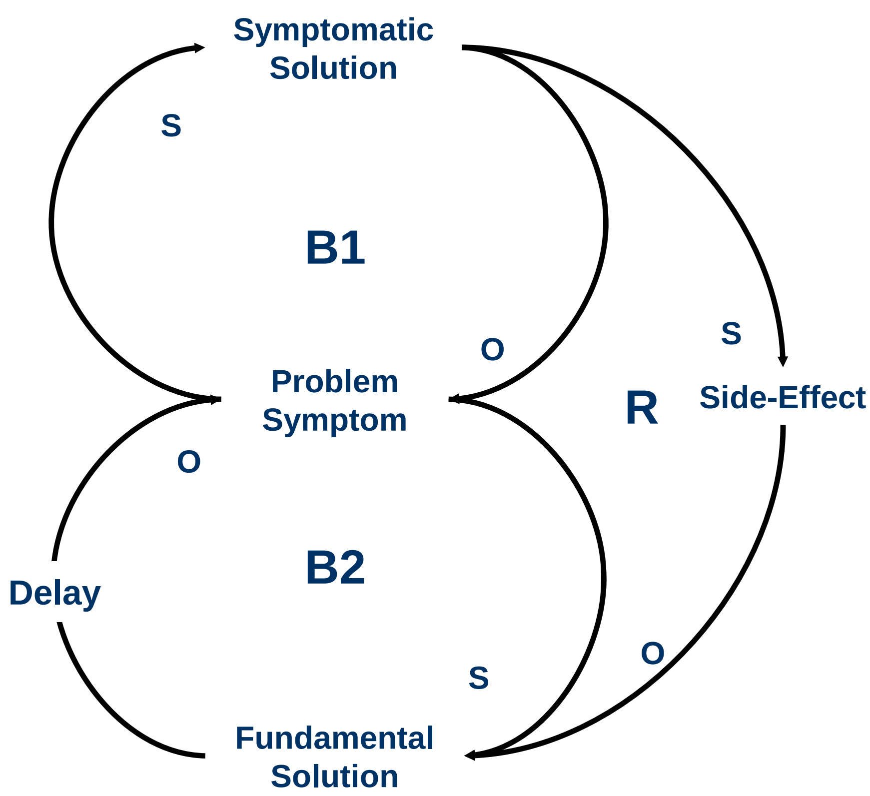
"Fixes That Fail" – Systems Archetype



A quick *Fix* for a *Problem Symptom* has immediate positive results, but also has long-term *Unintended Consequences* that, after a *delay*, worsen the original *Problem Symptom* as the *Fix* is used more often.

based on "Fixes That Fail"

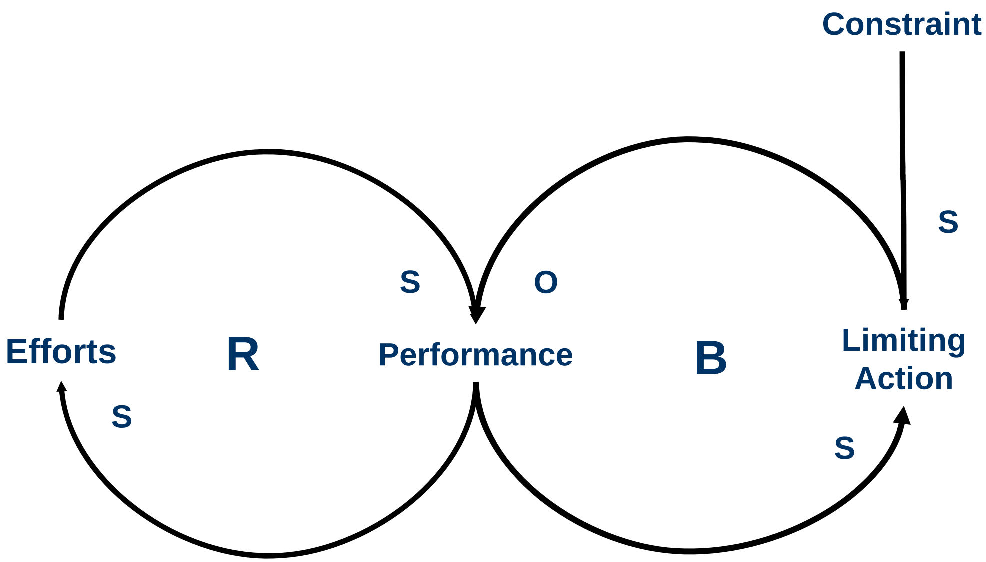
“Shifting the Burden” – Systems Archetype



A *Symptomatic Solution* temporarily solves a *Problem Symptom*, which later recurs. Its repeated use over the longer term has *Side-Effects* that make it less and less feasible to use the more effective *Fundamental Solution*—trapping the organization into using only the *Symptomatic Solution*. Impatience with the delay makes the organization choose the *Symptomatic Solution* in the first place.

Based on “Shifting the Burden”

“Limits to Growth” – Systems Archetype



Initially rapid growth slows because of an inherent capacity limit in the system that worsens with growth. As greater *Efforts* produce better *Performance*, there is a greater *Limiting Action* due to a *Constraint* in the environment, slowing *Performance*.

Based on “Shifting the Burden”

Acquisition Archetypes

There are many recurring patterns of behavior in software acquisition and development that have been modelled using Systems Archetypes and CLDs:

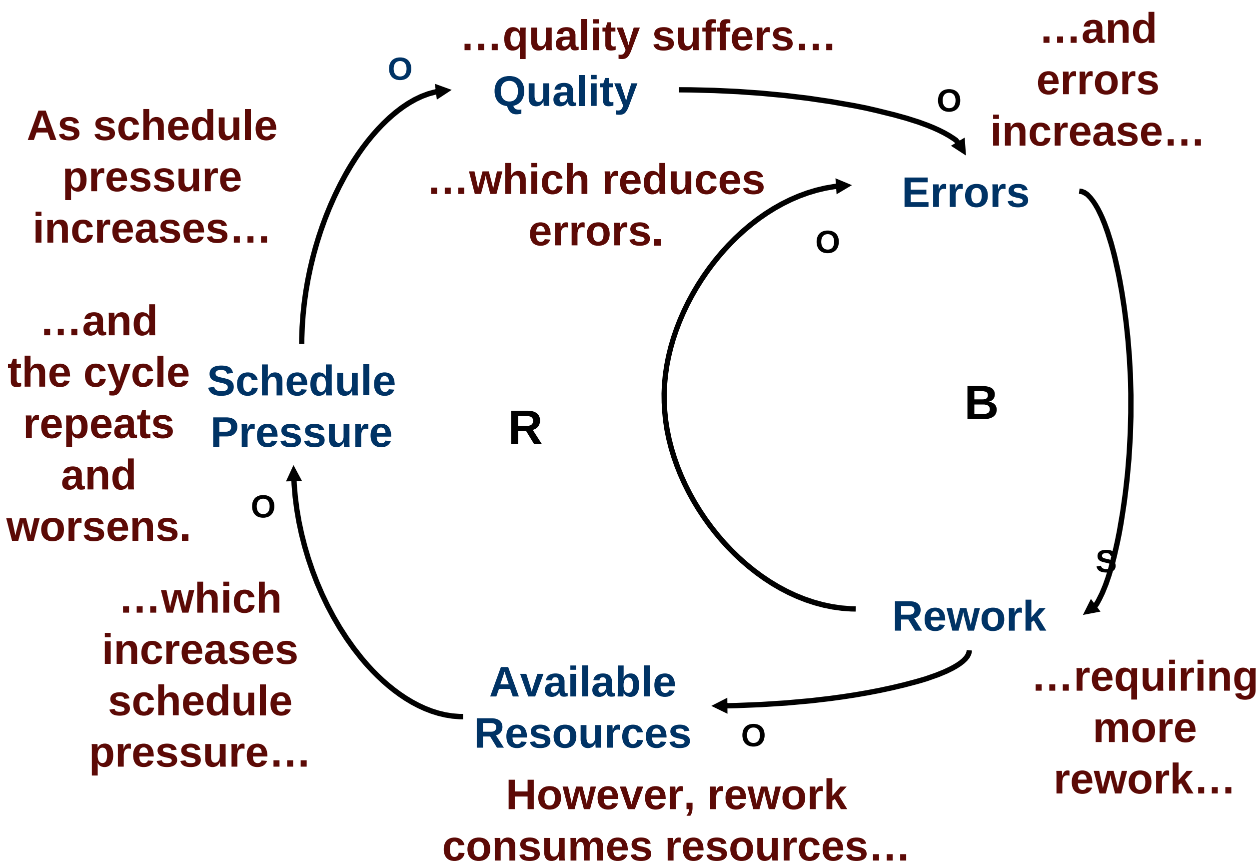
- Sacrificing Quality
- Firefighting
- The "Bow Wave" Effect
- Underbidding the Contract
- Shooting the Messenger
- Robbing Peter to Pay Paul
- Longer Begets Bigger

. . .

- The 90% Syndrome
- Requirements Scope Creep
- Feeding the Sacred Cow
- Brooks' Law
- PMO vs. Contractor Hostility
- Staff Burnout and Turnover
- The Improvement Paradox

. . .

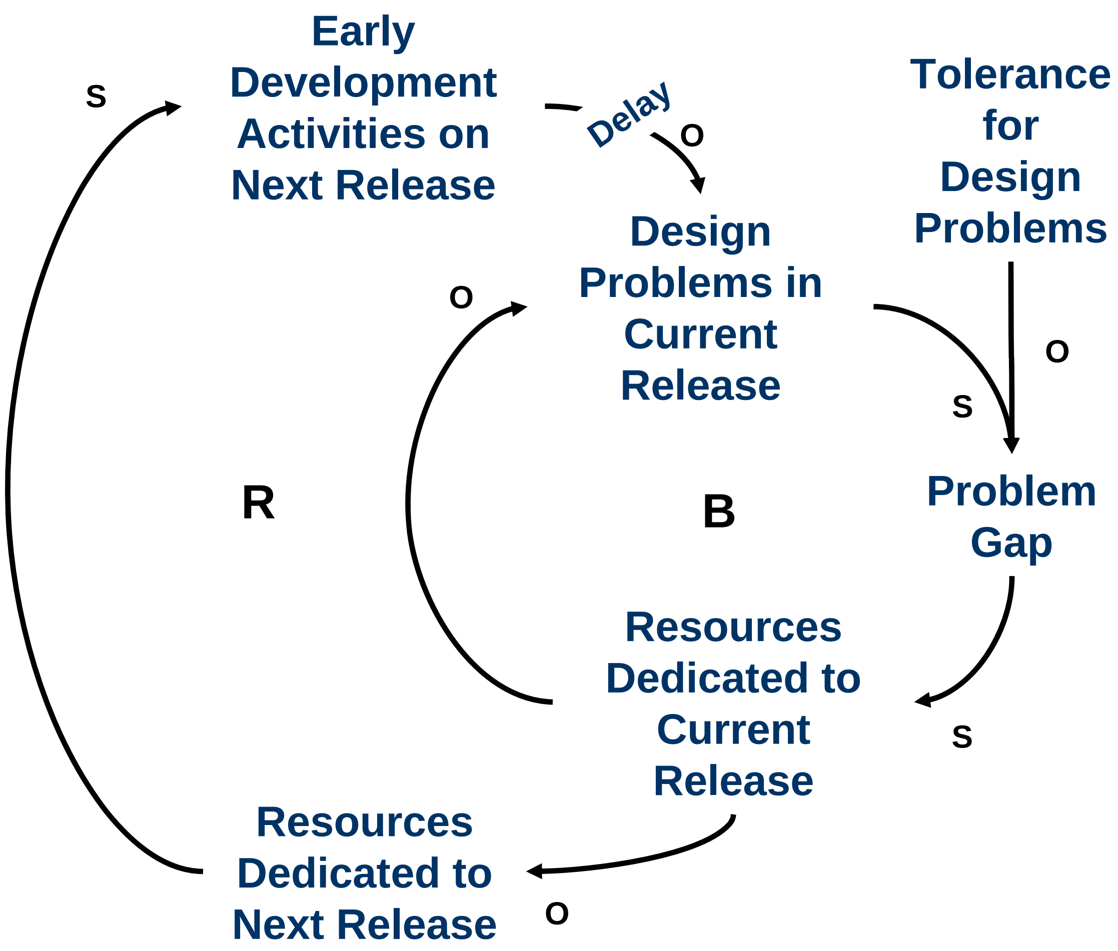
“Sacrificing Quality” – Acquisition Archetype



As schedule pressure increases, processes are shortcut, quality suffers, and errors increase—requiring more re-work. However, re-work consumes resources, which increases schedule pressure, and the cycle repeats and worsens.

based on “Fixes That Fail”

“Firefighting” – Acquisition Archetype

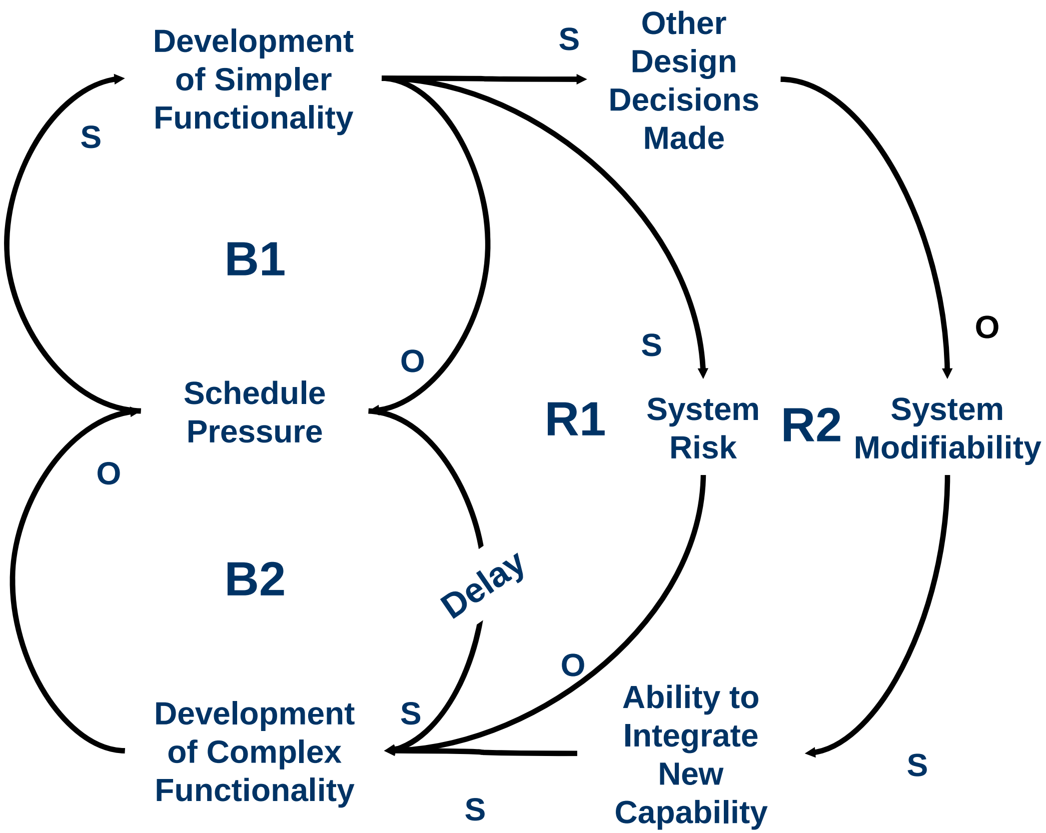


If a design problems in the current release are higher than the tolerance for them, more resources must be dedicated to fix them. This reduces problems, but now fewer resources can work on the *next* release. This undermines its early development activities which, after a delay, increases the number of design problems in the next release.

from “Past the Tipping Point”

based on “Fixes That Fail”

"Bow Wave Effect" – Acquisition Archetype



Risky tasks planned for an early spiral to reduce risk are postponed to a later spiral, making near-term performance look better. This increases risk in subsequent spirals by delaying required risky development for which there is now less available schedule to address potential issues, and less flexibility in the system to accommodate changes needed to integrate the new capability.

based on "Shifting the Burden"

The Bigger Picture/Breaking the Pattern

By showing the underlying structure of a dynamic, Causal Loop Diagrams show where best to apply leverage to slow or stop it—for example:

- Change negative dynamics into positive ones by running them backwards
- Slow the acceleration of unwanted reinforcing loops—"*When you're in a hole, stop digging*"
- Change the limiting value a balancing loop approaches or oscillates around to something more acceptable.

Each systems archetype has specific interventions for addressing it

Knowing about the most common counter-productive dynamics is the best way to prevent them

Acquisition Archetype Concept Briefs

SEI is producing a set of "*Acquisition Archetype*" concept briefs, analyzing recurring patterns in actual acquisition programs, and recommending interventions and preventative actions

Next Steps and Further Information

Extend the set of *Acquisition Archetypes*

- Eleven *Acquisition Archetypes* have been described to date
- Plan to identify additional acquisition dynamics and root causes

For additional information

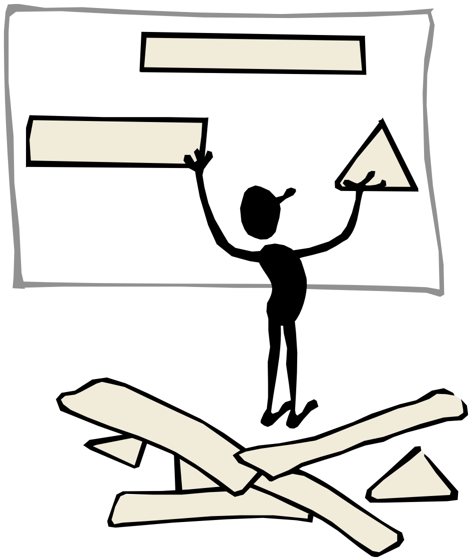
- Visit the SEI website:
  - http://www.sei.cmu.edu/programs/acquisition-support/pof-intro.html
- Upcoming SEI Technical Note: "*Archetypal Patterns of Failure in the Acquisition and Development of Software-Intensive Systems*"
- Planned 2008 Workshop: "*Avoiding Failure in Software Acquisition*"

Federal Information Security Management Act (FISMA) Operational Controls and Their Relationship to Process Maturity

Ronda Henning
rhenning@harris.com

The Basic Premise of This Presentation

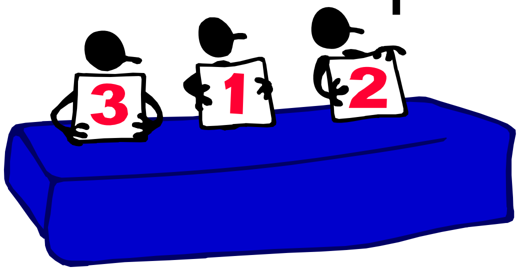
- Proper preparation and planning makes later phases of the System Development Life Cycle easier to conquer.



NOTE: FISMA is used as a representative standard. Insert the security guidance document of your choice in the context of this presentation.

About FISMA

- The Federal Information System Management Act (FISMA)
- Consists of 17distinct families of security requirements
- Mandates quarterly vulnerability reporting and annual progress reports to GAO
- The framework for how to report is left to the interpretation of the parent agency

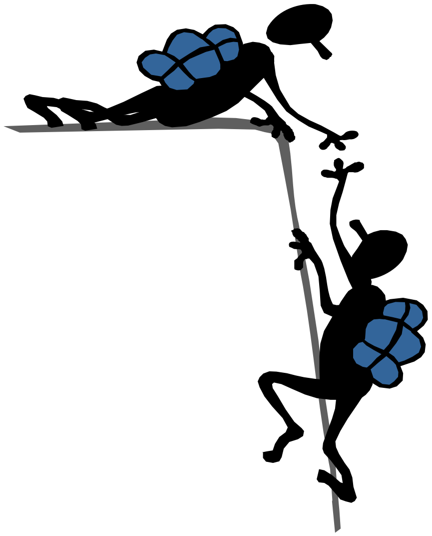


FISMA Control Families

Management Controls
- Risk Assessment
- Planning
- System and Services Acquisition
- Certification & Accreditation (C&A)

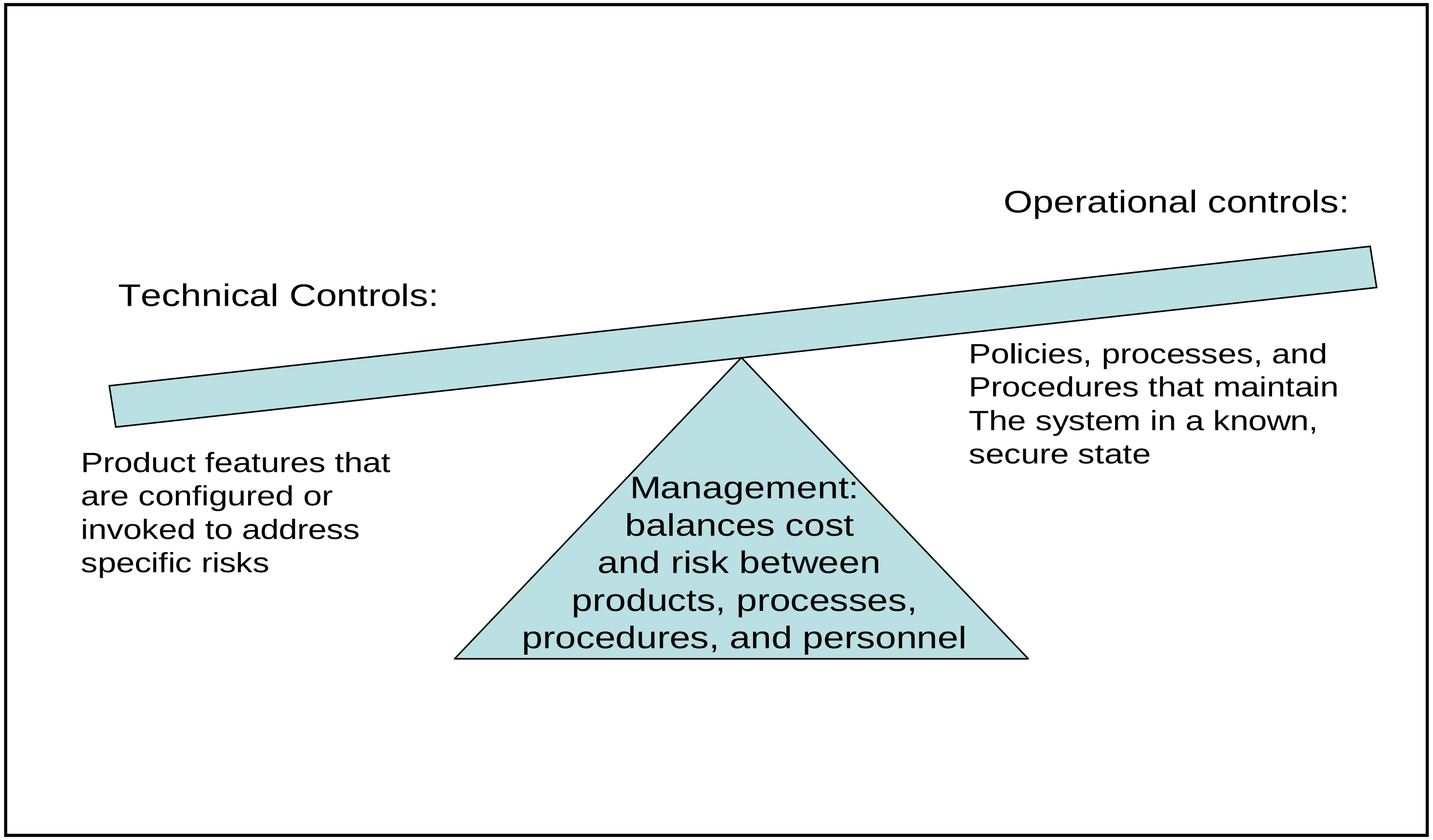
Technical Controls
- Access Control
- Audit and Accountability
- Identification and Authentication
- System and Communications Protection

Operational Controls
- Awareness and Training
- Configuration Management
- Contingency Planning
- Incident Response
- Maintenance
- Media Protection
- Physical and Environmental Protection
- Personnel Security
- System and Information Integrity



Controls are Complementary and rely on each other for fulfillment

Relationship among controls



Operational Controls

- People Oriented
  - Awareness and Training
  - Personnel Security
- Physically Oriented
  - Environmental Controls
  - Media Protection
  - System Integrity
  - Contingency Planning
- Device Oriented
  - Configuration Management
    - Software
    - Firmware
    - Hardware
  - Maintenance
    - Routine
    - Emergency
  - Incident Response
    - What is an incident?
    - Reactive v. Proactive actions
  - System & Information Integrity
    - Is the data corrupted?
    - Is the system image valid?
    - Are they current/accurate?

Device Oriented Requirements

- Harder to address later in SDLC
- Frequently neglected in development
- Reason:
  - It’s hard enough to get the system integrated and working, planning for later operations is left to the student.
- In reality:
  - Planning ahead is the best way to maintain a proactive assurance posture

Security Objective of Device Controls

- Define and maintain a known, secure state
  - At delivery and ongoing
- Systems are integrated products
  - Each vendor has their own set of quality and security processes
  - Monthly patches, quarterly patches, emergency patches
  - Options are:
    - Working system with vulnerabilities
    - Semi-functioning system without testing
    - Cross your fingers and hope!
      - Everything works with the patch and no testing
      - Nobody tries to exploit the problems before you fix them

In the Ideal World

Vendor patch released

- What is affected?
- What is the risk?

Command Assessment

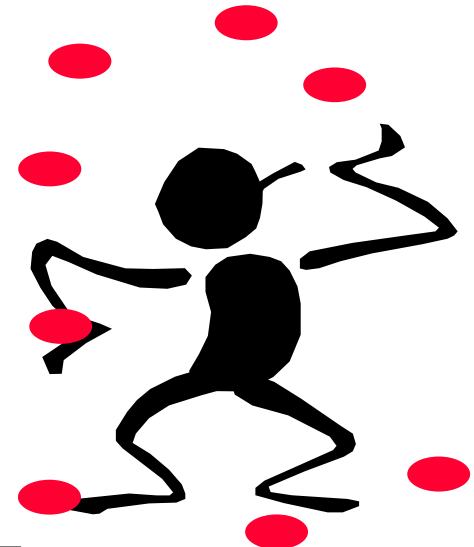
- Add to standard?
- Push changes out

Application Factory Triage

- Regression testing
- Impact assessment

Add to Baseline Configuration

- Update DM
- New standard



In reality:

N vendors per system

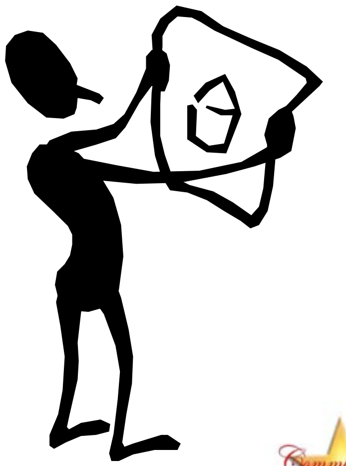
Different release schedules

N software applications

System may have over 100 products.

- CMMI processes already include configuration management and change management
- What they may not include is specific processes associated with security change management
- Risk must be addressed in the process

- System Security Engineering CMM
  - Add security relevant functions to standard CMMI activities
  - Incorporation in an organization’s standard process framework is an incremental change
- A Caveat:
  - An incremental change that involves careful component management
  - Accounting at a more granular level
    - All the component software entities
    - Protocols, reference standards, etc.



Mapping Goals, KPAs and FISMA:

FISMA Control:

Specifies what must be managed, what artifacts should be produced for the system. Control defines the compliance baseline.

Maps to CMMI KPA

CMMI KPA:
Basic process guidance & structure

Specific Guidance for Security Engineering

SSE-CMM KPA:

- Manage Configuration of Security Components.
- Assess security impact of change?
- Define change management process
- Assess risk associated with change?
- Document risk decisions

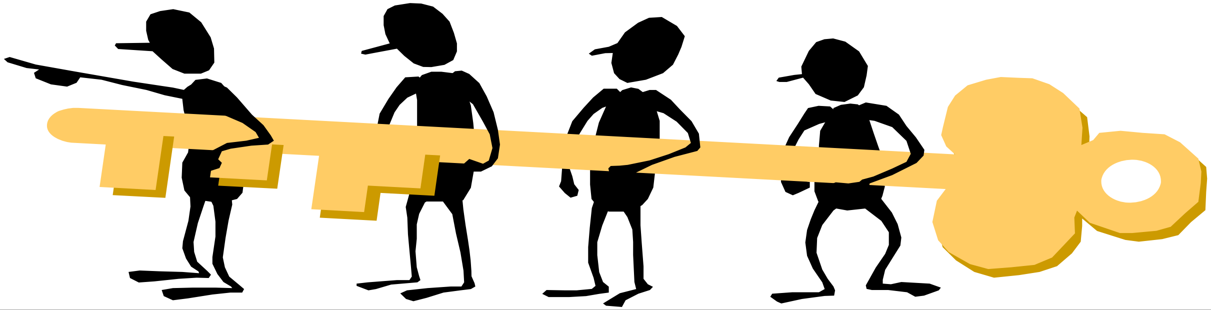
Implications

- Augmentation to existing process means higher probability of organizational acceptance
- Does not imply use of automated techniques: although they are easier with larger systems and global deployments
- Areas for automation:
  - Asset inventory
  - Baseline configuration tracking
  - Vendor notification and update service
  - Deployment tracking

Further Implications

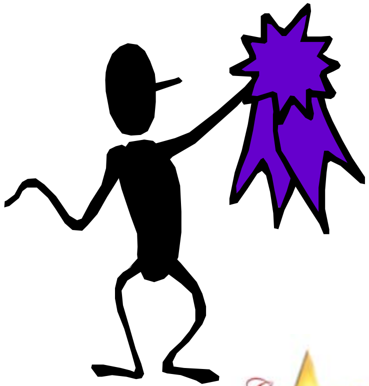
- Starting process management at authority to operate is too late.
- The baseline is established by then.
- May not have been monitored and upgraded throughout development.
  - It's hard to develop code on a moving target
  - Vulnerabilities may be inadvertently used as part of the system feature set
  - Compromises need to be documented

- FISMA families explain what has to be done (tangible product)
- CMMI provides the contextual framework for inclusion of FISMA families in an integrated set of engineering processes
- SSE-CMM defines specific process guidance that helps an organization develop the product



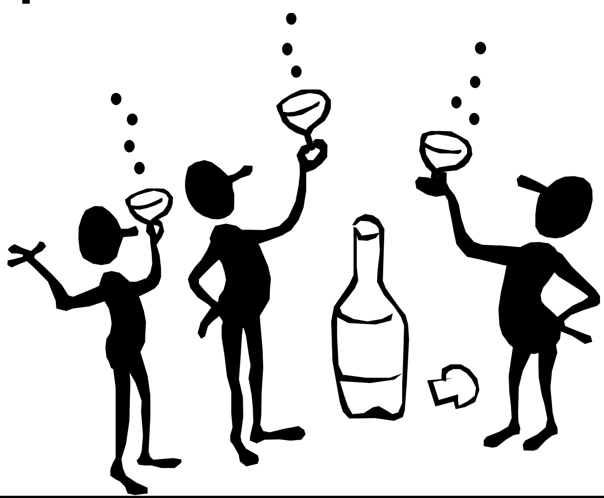
In Summary

- Exact correspondence will vary:
  - Some organizations won't address all goals.
  - Compensating management controls can be traded against technical controls
- Goal is to define repeatable process:
  - Certification and accreditation required every 3 years
  - Ongoing monitoring requirements on an annual basis
  - Simpler to accommodate the requirements within existing processes
  - SSE-CMM and CMMI provide guidance and placeholders that can facilitate compliance



Conclusion

- Starting from a secure foundation is easier than trying to shore up an unsound one.
- Framework for security improvement is already there – but not applied.
- Process maturity dictates that we learn from our experiences and evolve.



For More Information

- FISMA:
  - www.csrc.nist.gov
- SSE-CMM:
  - www.issea.org
- CMMI:
  - www.sei.cmu.edu

An Update on the DT&E Committee's Recommended Policy Changes to DoD 5000

Col. Richard Stuckey
Mr. Tom Wissink
Mr. John Lohse

October 23, 2007

Current Events

- FY2007 DoDI 5000.2 Update
  - "Fact-of-life" changes – existing policy memos
  - No significant impact to our efforts
- FY2007 NDAA Section 231 Report
  - Report to Congress on T&E Policy & Practices
    - Focus on new/emerging acquisition approaches
    - Policy changes TBD

Current Events (cont)

- DT&E Defense Science Board
  - Formed to look at DT&E roles, practices
  - Focus on improving readiness for IOT&E
  - No impact on our efforts
- NDIA SED DT&E Committee Focus on DoD 5000 Recommended Policy Changes
  - These efforts provide complementary or alternative view

Current Events (cont)

DRAFT POLICY WOULD BRING ‘OPERATIONAL FLAVOR’ TO WEAPON TESTING:

“. . . By incorporating more ***realistic*** tests of system reliability throughout the development process, officials hope to reverse a recent trend where fewer and fewer platforms meet operationally suitable and effective standards . . .”

Quote from Charles McQueary, the military’s director of Operational Testing and Evaluation (DOT&E), told reporters Oct. 19. (DefenseNews.com)

Current Events (cont)

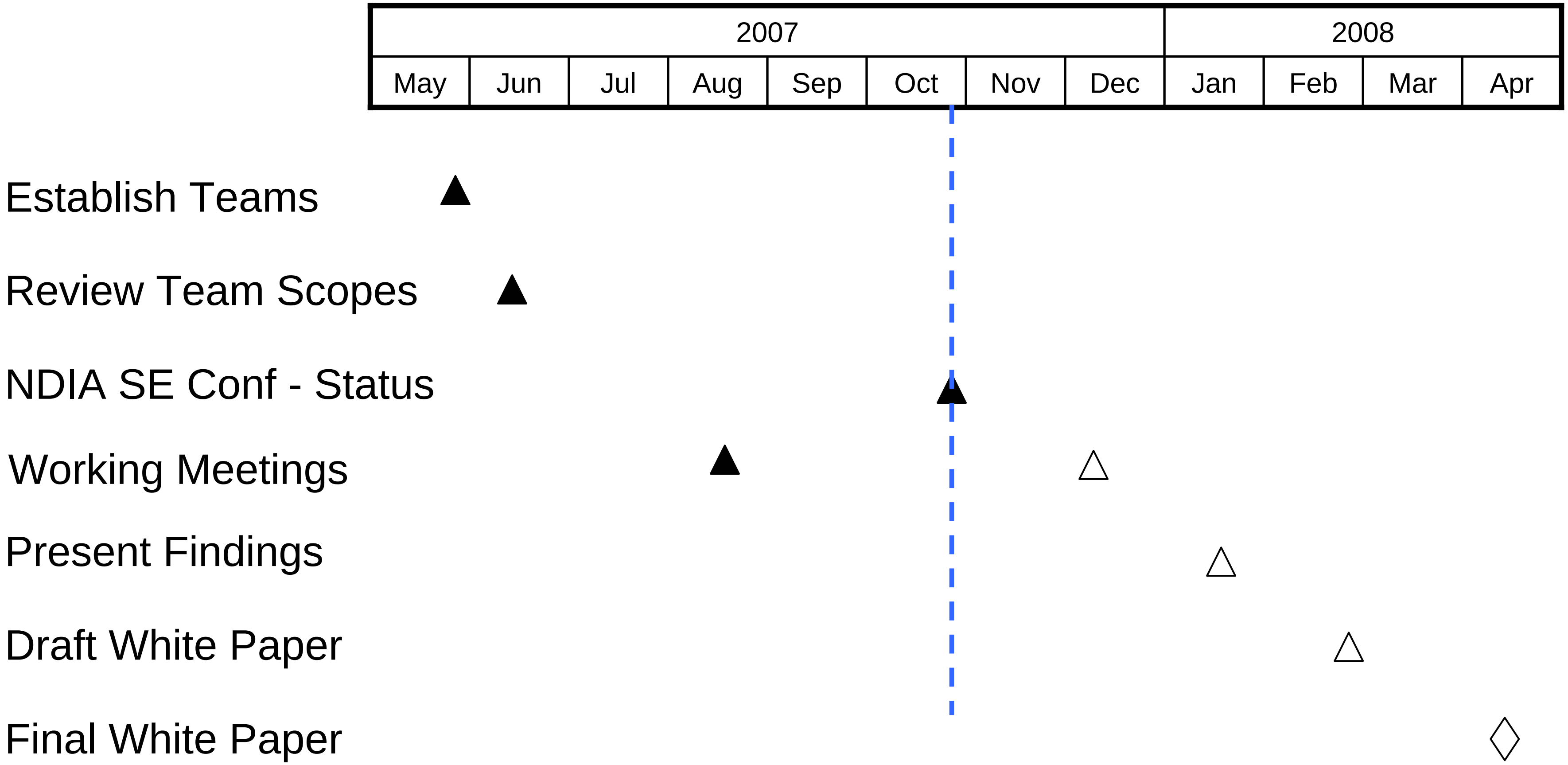
From Yesterdays SE Conference Opening Session, October 23, 2007:

- Dr McQueary’s chart – Actions to improve Suitability includes the DT&E Committee White Paper
- Dr Finley made a comment about strong DT&E prior to milestone C

2007 DT&E Committee Focus

- **Three Focus Teams:**
  - Earlier contractor and tester involvement
  - Integrated DT/OT and DT operational relevance (combined)
  - Suitability
- **Recommend policy changes**
  - Input to FY2008 DoD 5000 update

Project Timeline



Focus Team Expectations

- Teams expected to collaborate between DT&E Committee meetings and present findings at the meetings
  - Collaborate via e-mail, telecon, etc.
- Product is a White Paper on DT&E policy change recommendations
  - Draft outline available

Focus Team Expectations

- October Meeting (in San Diego)
  - Initial draft white paper outline
- Workshop (tentatively January 23-24, 2008)
  - Initial draft of white paper
  - Recommendations presented to stakeholders for comment
  - Recommendations sent out to NDIA SED members for comment
- April 2008 Submittal
  - Team leads incorporate stakeholder and SED member comments, prepare final recommendations, and submit through NDIA SED

Earlier Contractor and Tester Involvement

- Identify the “T&E Community” to include both contractor and government DT, OT and Live Fire (LF) organizations
- The T&E Community needs to work in collaboration with the Acquisition Community in the earliest phases and decision points of the acquisition process.
  - Make T&E Community participation and products mandatory at all early phases
  - Involved the T&E Community as early as the Concept Definition phase of a program. This needs to be detailed in the JCIDS process.

Earlier Contractor and Tester Involvement

- The Test & Evaluation Strategy (TES) is developed too late in the acquisition process.
  - The TES should be mentioned in the Acquisition Strategy and fully developed by the T&E Community prior to the system RFP/SOW.
- Awareness of test readiness is lacking as a program matures.
  - Develop a Test Readiness Level hierarchy similar to technology readiness levels and implement as part of Concept Definition.
- Need earlier incorporation of the TEMP in the acquisition process.
- There is a lack of visibility between the various T&E organizations across the T&E phases.

Integrated DT/OT and DT Operational Relevance

- Current 5000.2 allows for a wide variety of integrated testing strategies – it needs to provide more specific direction
- Need to ensure clearly defined terms – Joint DT/OT, Integrated DT/OT, Combined DT/OT, etc.
  - There are current definitions but not necessarily totally agreed to yet across agencies
    - DAU is a way to work the commonality of terms
  - Some of the biggest issues are cultural between the different stakeholders

Integrated DT/OT and DT Operational Relevance

- Several items from this team are very similar to Team 1
  - Earlier involvement & Funding needed
  - Need to understand all the Stakeholders (i.e. the T&E Communities that should be involved)
- Specific TEMP sections for integrated T&E need to be included & coordinated sooner with agreed to terminology, timelines, etc
  - Need PM & T&E in-sync on integrated T&E
  - How to transition from sequential events to a more integrated/concurrent T&E process

Suitability

- High percentage of programs deemed operationally effective, but NOT suitable
  - Ensure system suitability is a key feature of T&E Program
  - Requirements flowdown must include user definition of mission failure and scoring criteria
  - Identify potential operational failure modes and their mission impact early

Suitability

- Make T&E more operationally relevant
  - Test entire system in operational environment and scenarios
- Reliability as part of the T&E Program
  - Require mandatory reliability growth and assessment program in Request For Proposal
  - Health of Reliability program considered in each program/technical review with award fee criteria

Summary

- Significant effort by T&E and Acquisition Communities to provide more successful testing across a weapon systems life cycle
  - FY2007 DoDI 5000.2 Update
  - FY2007 NDAA Section 231 Report
  - DT&E Defense Science Board
  - NDIA SED DT&E Committee Focus

Change Management of UML-Based Systems Engineering Artefacts

David Price
US NDIA SE Conference October 2007
David.Price@eurostep.com

Agenda

- UML® artefacts for SE, OMG SysML™
- Engineering Change Management
- A Standard Approach to Change Management for SysML
  - ISO AP233

Trademark Notice

UML artefacts for SE, OMG SysML

The “U” means “Unified”

- In the beginning, there were several software engineering diagramming techniques
  - largely pretty pictures for human consumption
- Unified Modeling Language (UML®)
  - is their merger/standardization in the Object Management Group (OMG™)
  - includes numerous diagrams
  - includes rigorous underlying model of the information contained on those diagrams
  - is extensible, can tailor UML to create new languages called UML Profiles

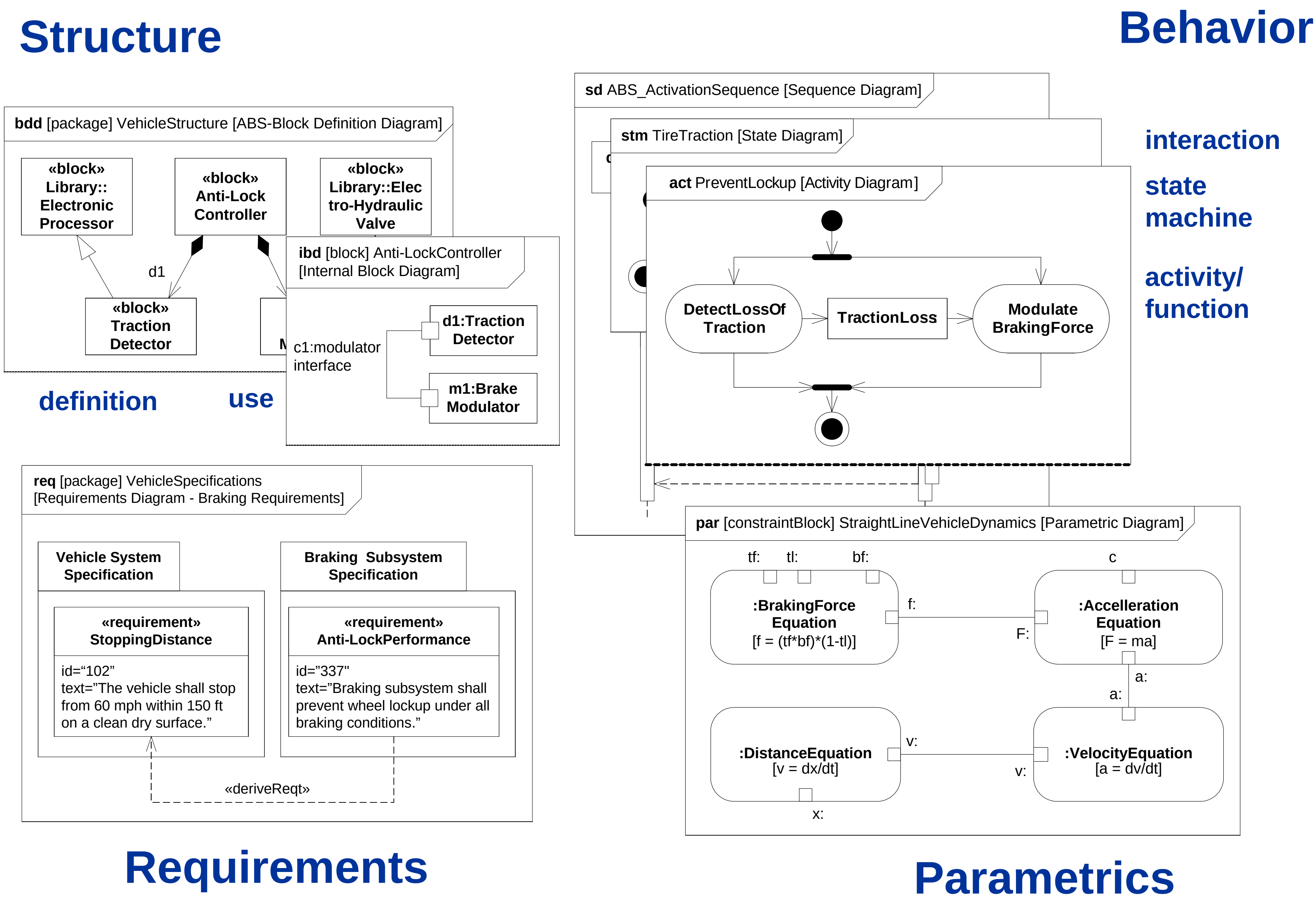
UML in Systems Engineering

- Some UML diagrams are useful outside the software engineering community
  - E.g. State machines to simulate systems behavior
- Organizations created methodologies for using UML in Systems Engineering
- SE community desired more commonality and so the OMG Systems Modeling Language (SysML) standard was born
  - Same thing happened for Systems Architecture and thus the OMG Unified Profile for DODAF/MODAF (UPDM) was born

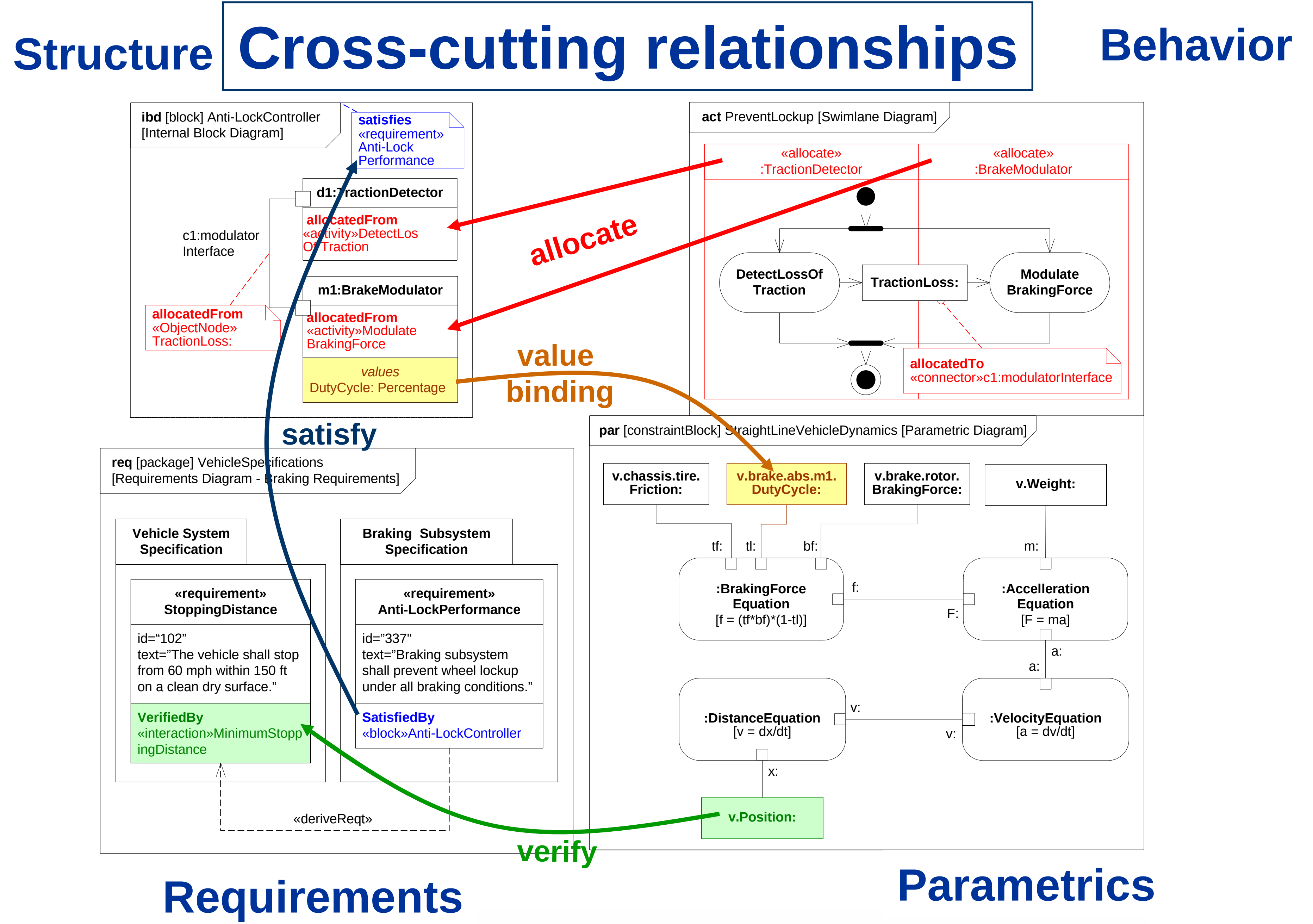
What is SysML?

- SysML is really two things
  - A set of graphical notations for modeling systems
  - A formal specification of the information content the icons on the diagrams represent
    - a subset UML language model with SE extensions

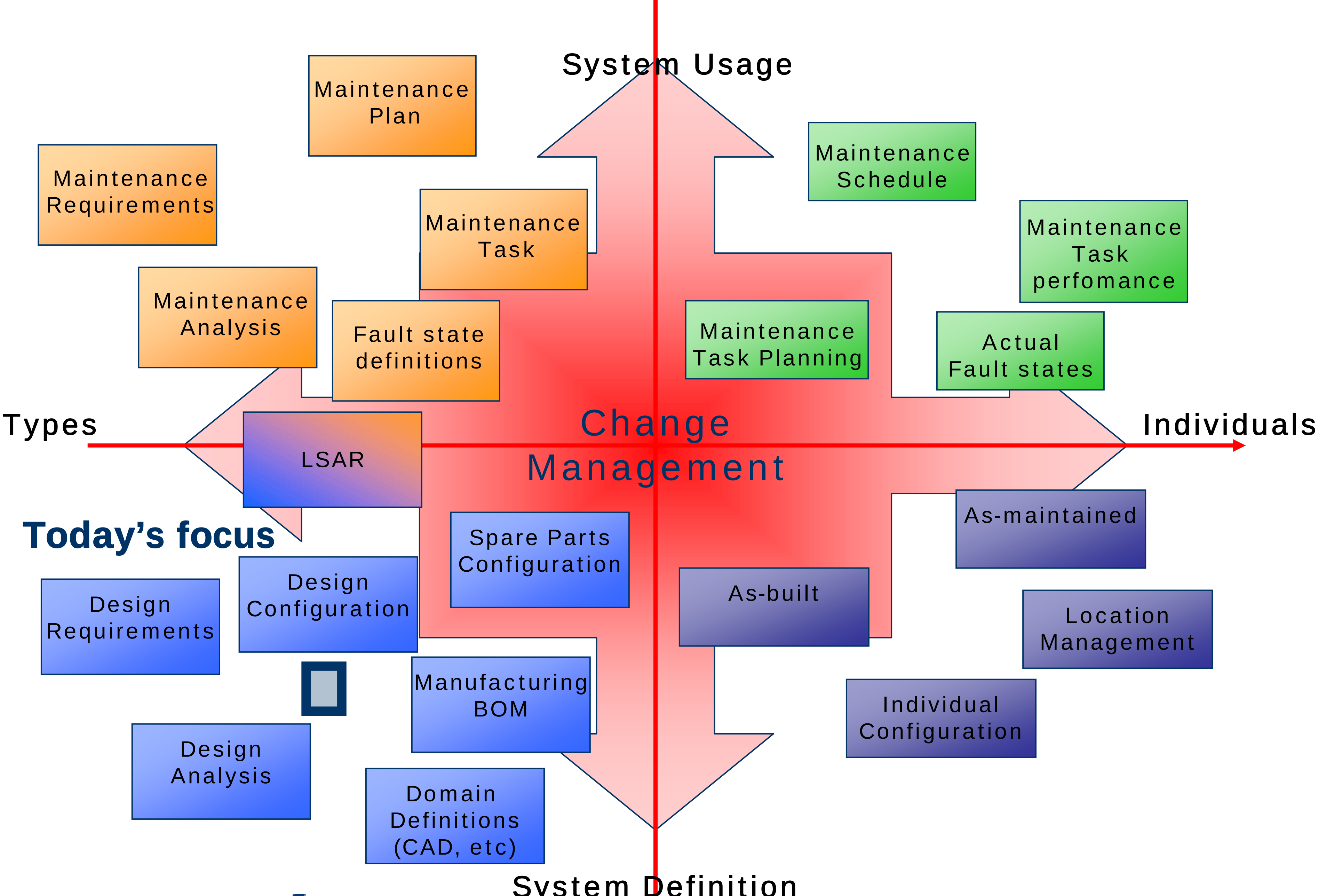
- SysML was developed in collaboration between INCOSE, OMG and ISO
  - SysML is a key step towards the Model Based Systems Engineering vision


Structure
Behavior
bdd [package] VehicleStructure [ABS-Block Definition Diagram]
«block» Library:: Electronic Processor
«block» Anti-Lock Controller
«block» Library::Electro-Hydraulic Valve
d1
«block» Traction Detector
ibd [block] Anti-LockController [Internal Block Diagram]
c1:modulator interface
d1:Traction Detector
m1:Brake Modulator
definition
use
sd ABS_ActivationSequence [Sequence Diagram]
stm TireTraction [State Diagram]
act PreventLockup [Activity Diagram]
DetectLossOf Traction
TractionLoss
Modulate BrakingForce
interaction
state machine
activity/ function
req [package] VehicleSpecifications [Requirements Diagram - Braking Requirements]
Vehicle System Specification
«requirement» StoppingDistance
id="102"
text="The vehicle shall stop from 60 mph within 150 ft on a clean dry surface."
Braking Subsystem Specification
«requirement» Anti-LockPerformance
id="337"
text="Braking subsystem shall prevent wheel lockup under all braking conditions."
«deriveReqt»
par [constraintBlock] StraightLineVehicleDynamics [Parametric Diagram]
tf:
tl:
bf:
c
:BrakingForce Equation
[f = (tf*bf)*(1-tl)]
f:
F:
:Accelleration Equation
[F = ma]
a:
a:
:DistanceEquation
[v = dx/dt]
v:
v:
:VelocityEquation
[a = dv/dt]
x:
Requirements
Parametrics

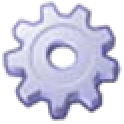
Cross-cutting relationships



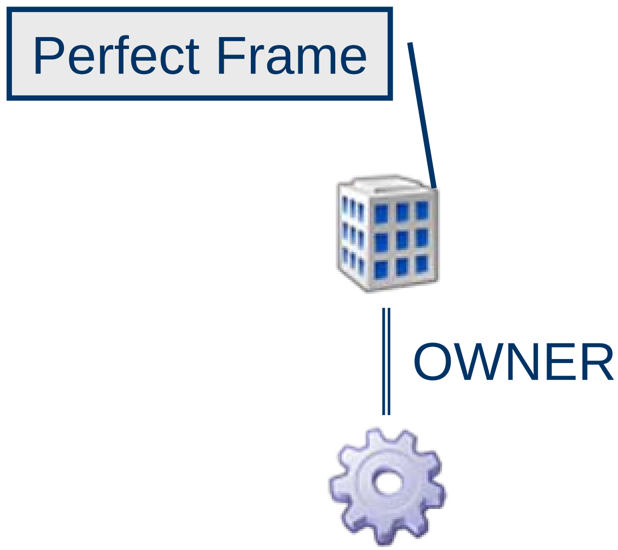
Engineering
Change Management


System Usage
Maintenance Plan
Maintenance Requirements
Maintenance Task
Maintenance Analysis
Fault state definitions
Maintenance Schedule
Maintenance Task perfomance
Maintenance Task Planning
Actual Fault states
Types
LSAR
Change Management
Individuals
Today's focus
Spare Parts Configuration
As-maintained
Design Requirements
Design Configuration
As-built
Location Management
Manufacturing BOM
Individual Configuration
Design Analysis
Domain Definitions (CAD, etc)
System Definition

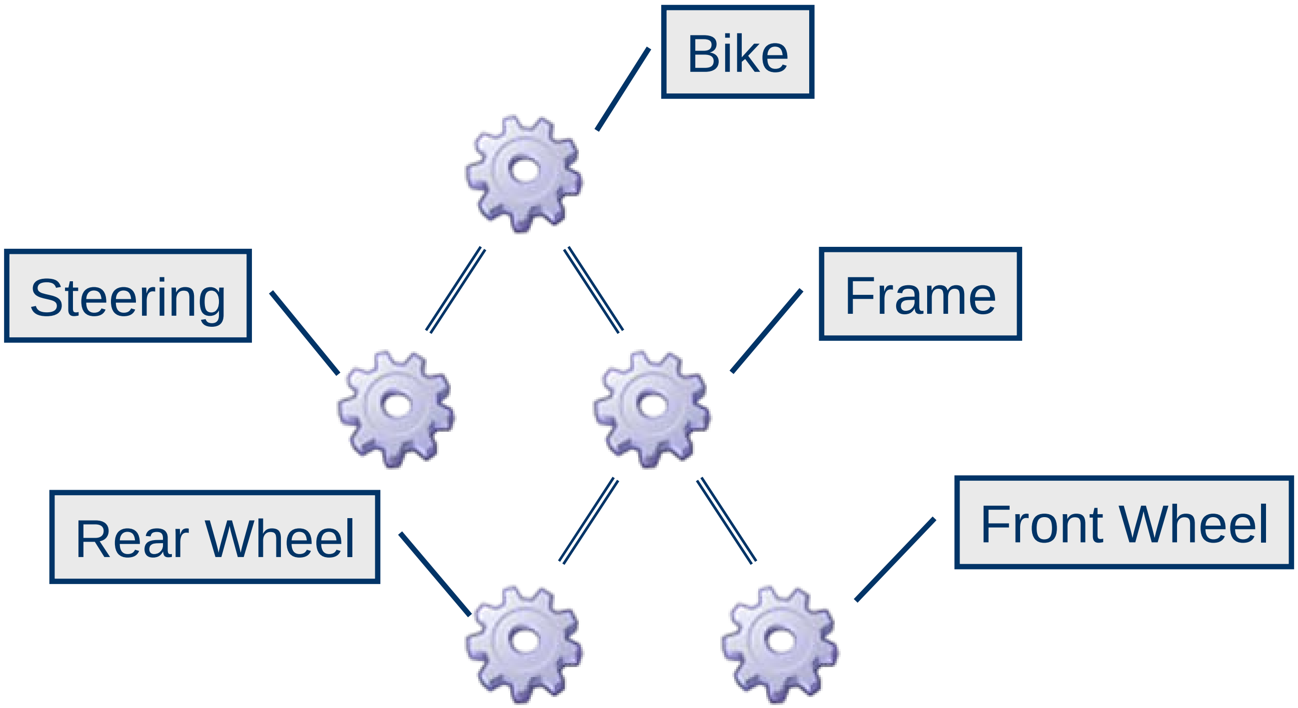
Item



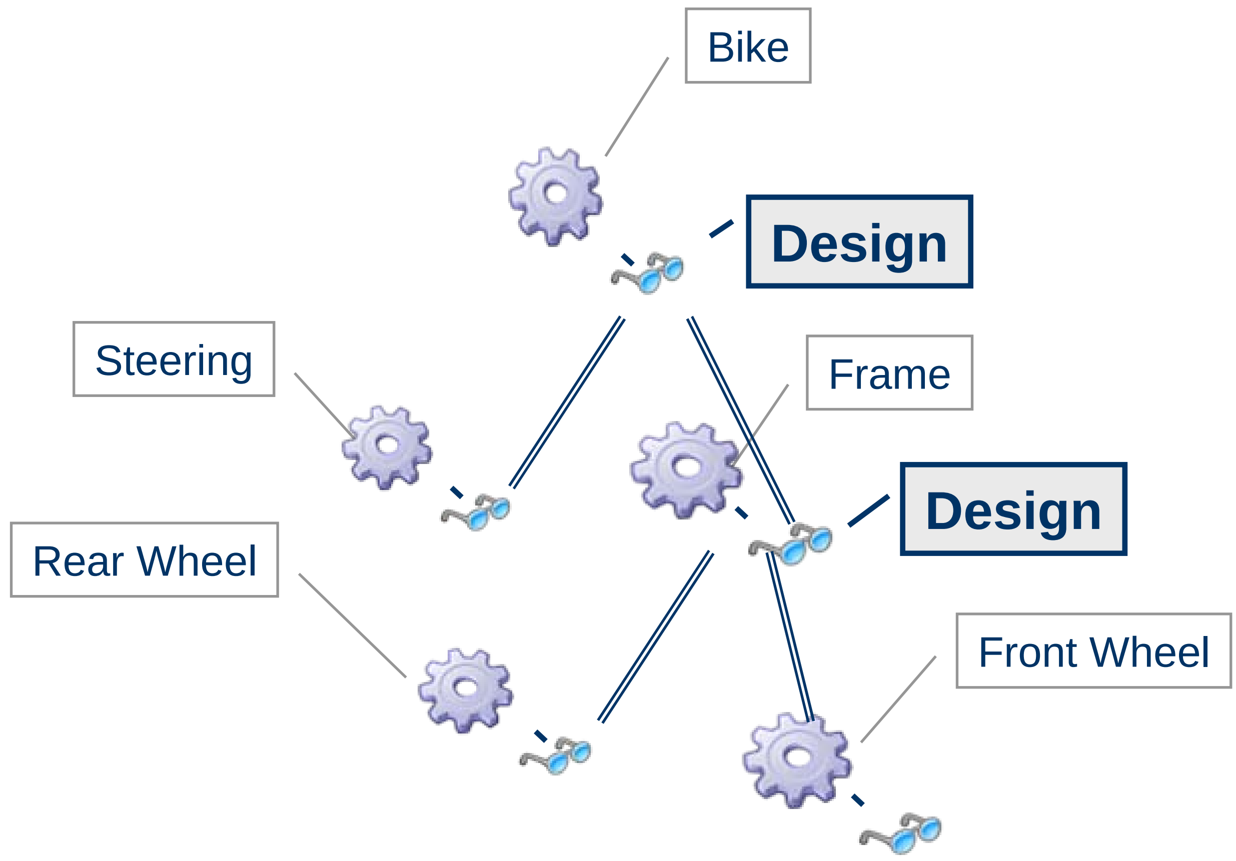
Item - Owner



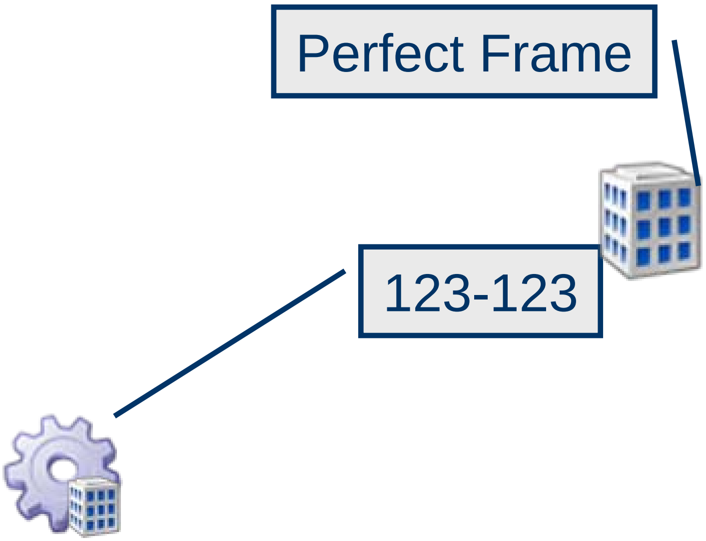
Structure - Basic



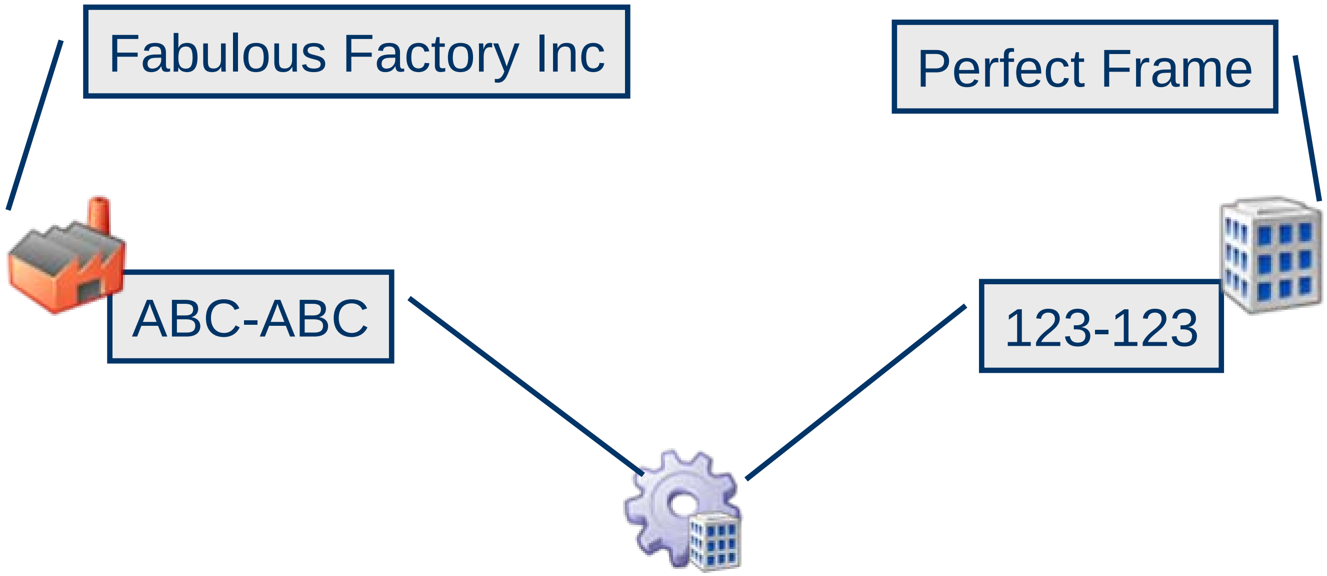
Structure – View Based



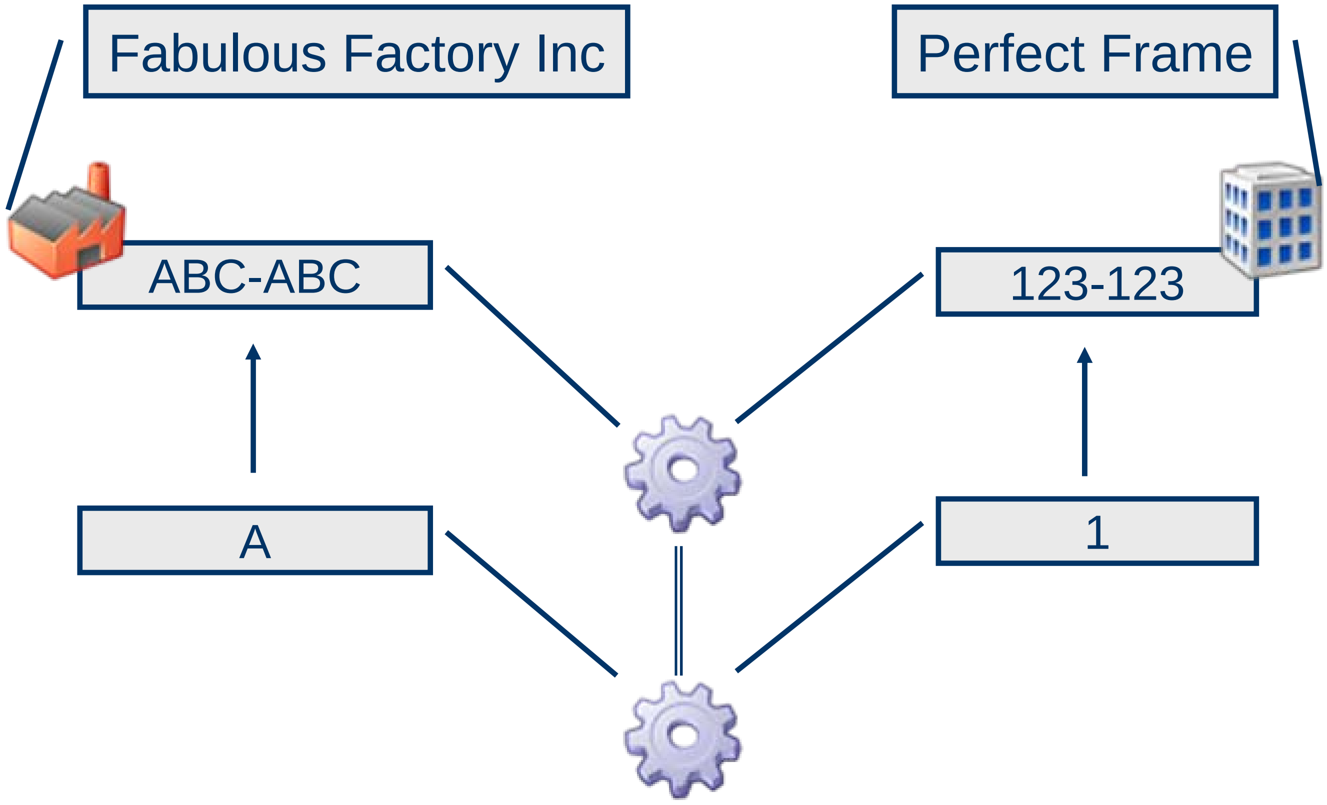
Item - ID



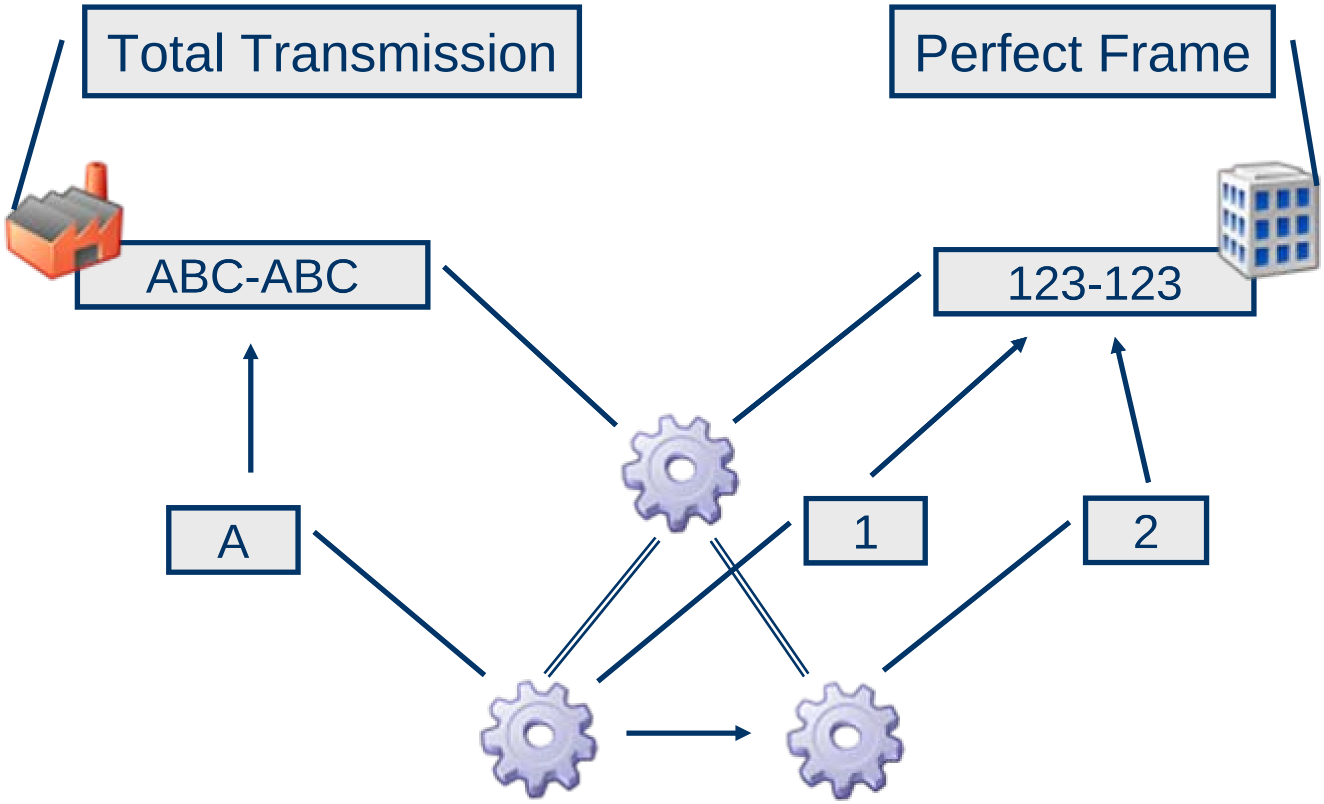
Item – Multiple ID



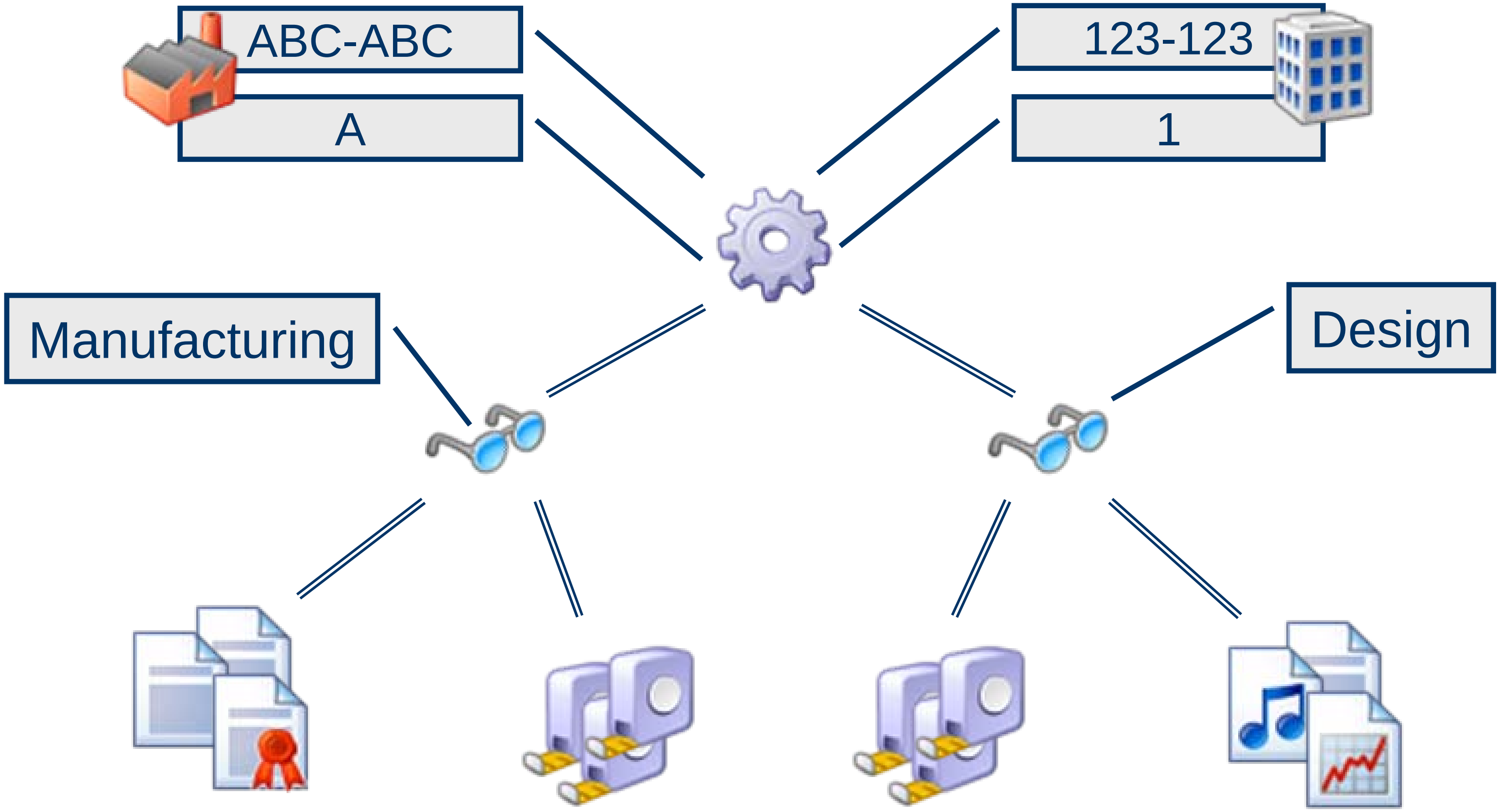
Item - Version



Item - Version 2



Item - Views



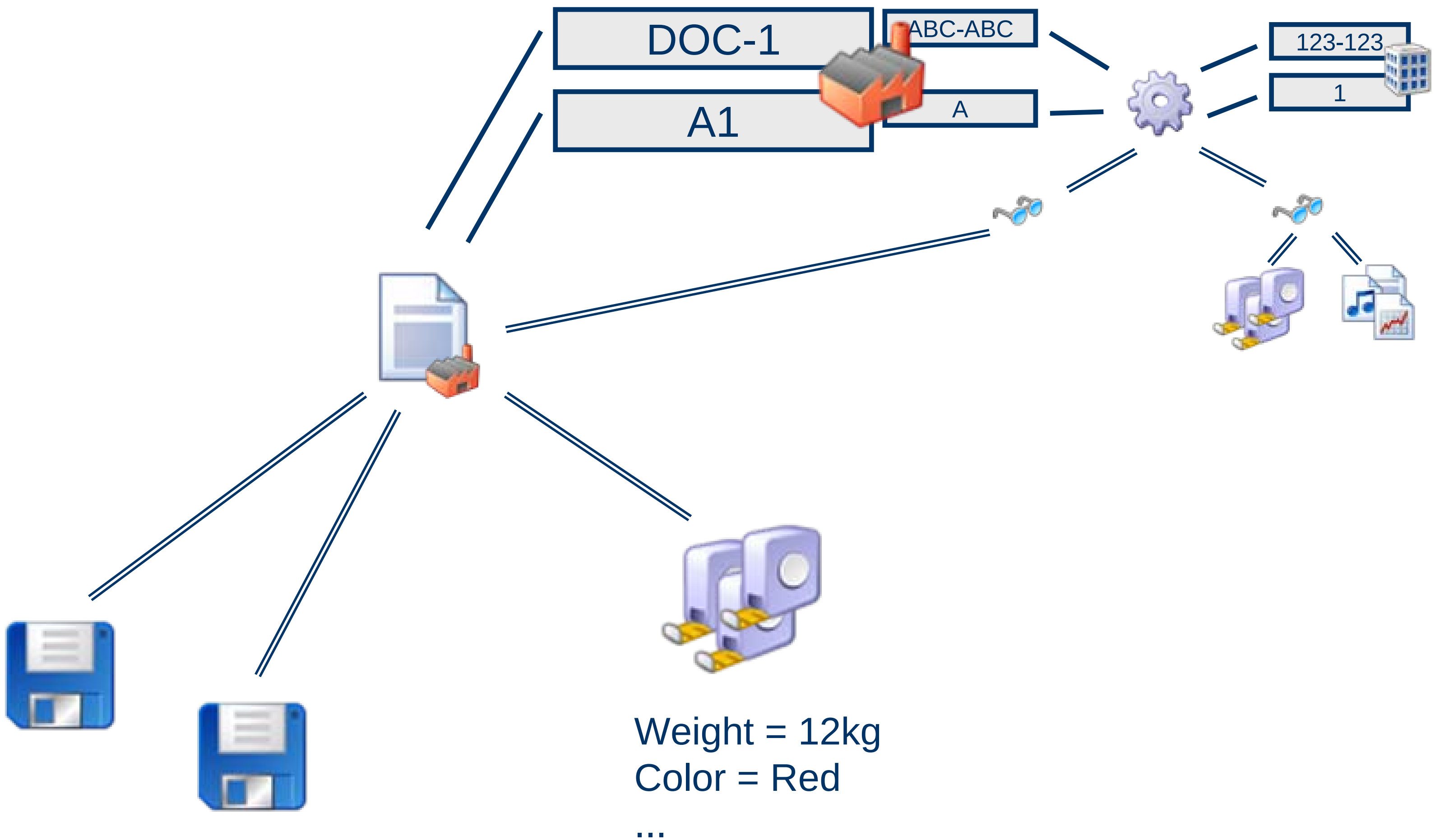
Assembly Instructions, ...

Weight = 12kg
Color = Red
...

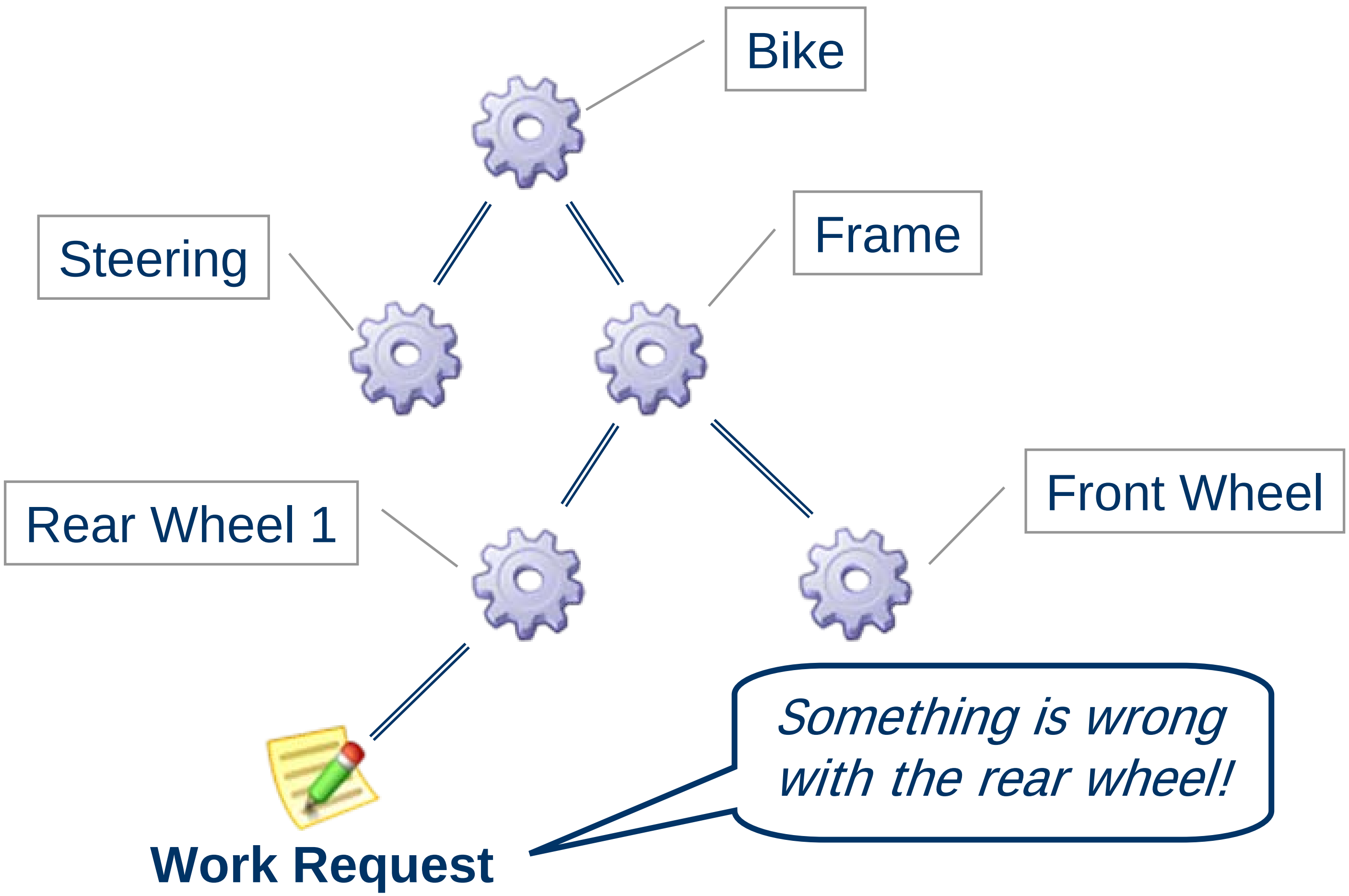
Height = 1234mm
Length = 4321mm
...

Drawings, Specifications, ...

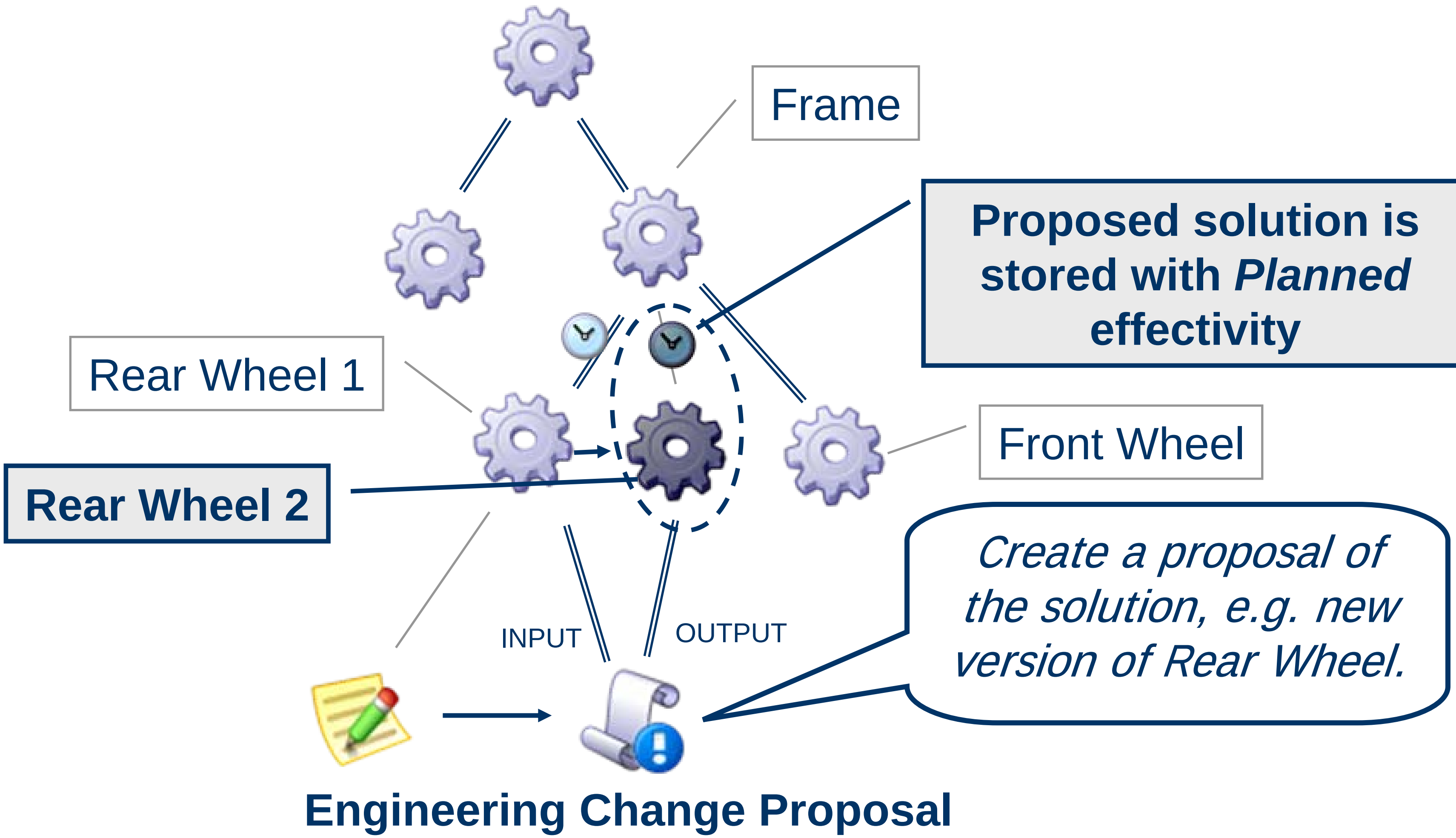
Document



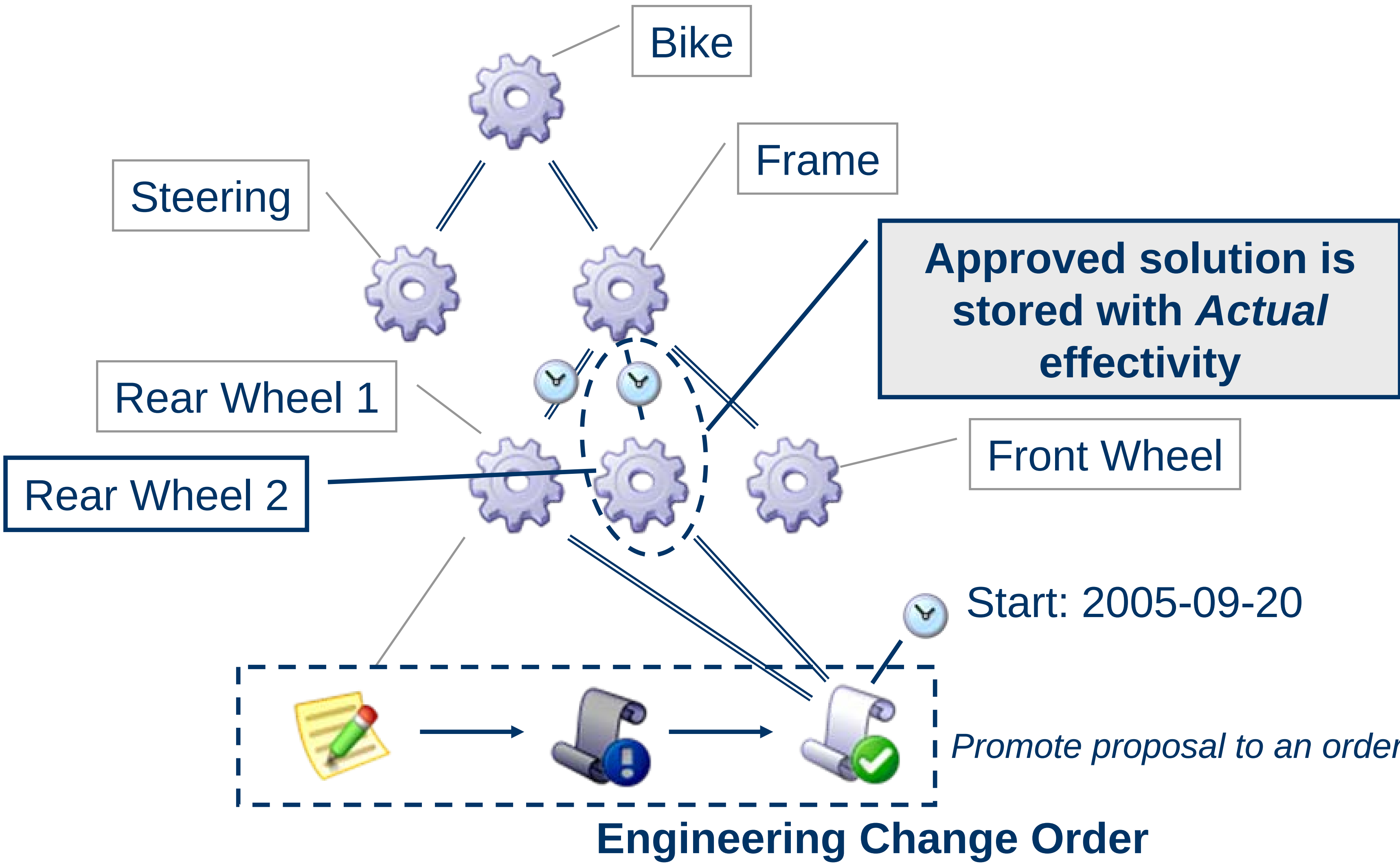
Change Management - Design



Change Management - Design

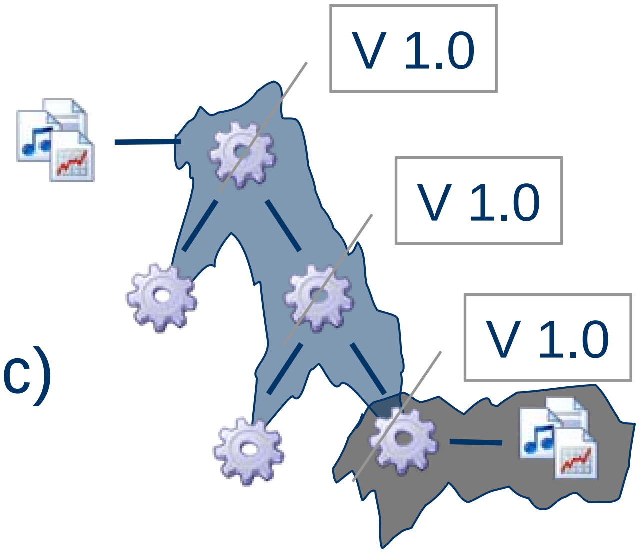


Change Management - Design



Freezing

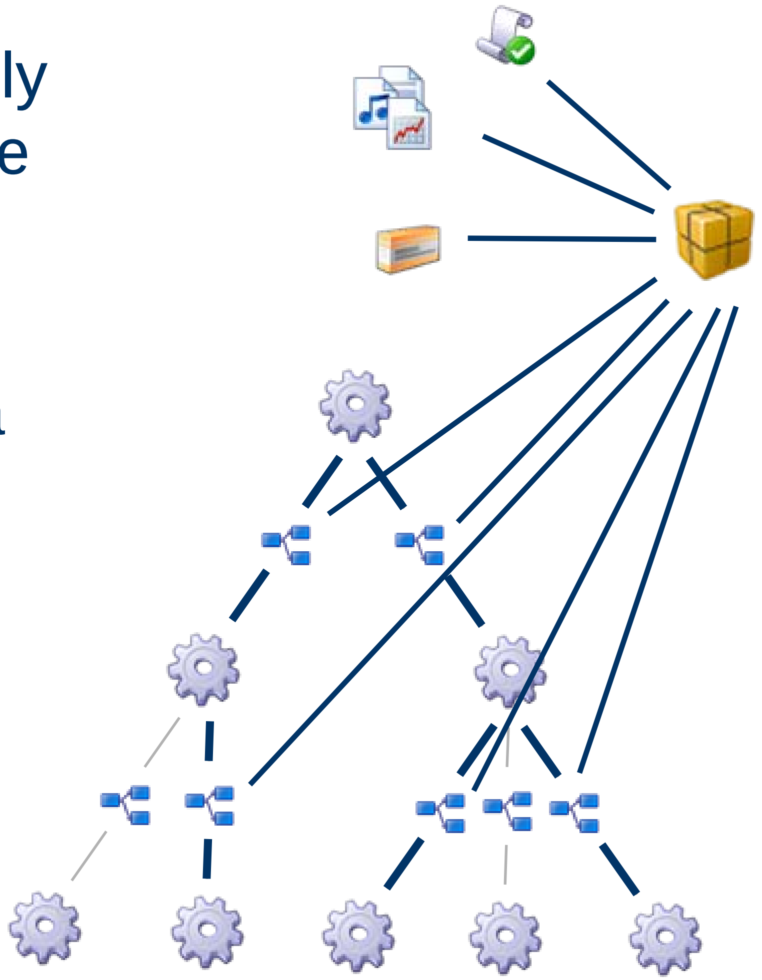
- Freezing is divided into two parts
  - Freezing Structure
  - Freezing Definitions (prop, doc)
- Freezing can be done on individual views



Baselining

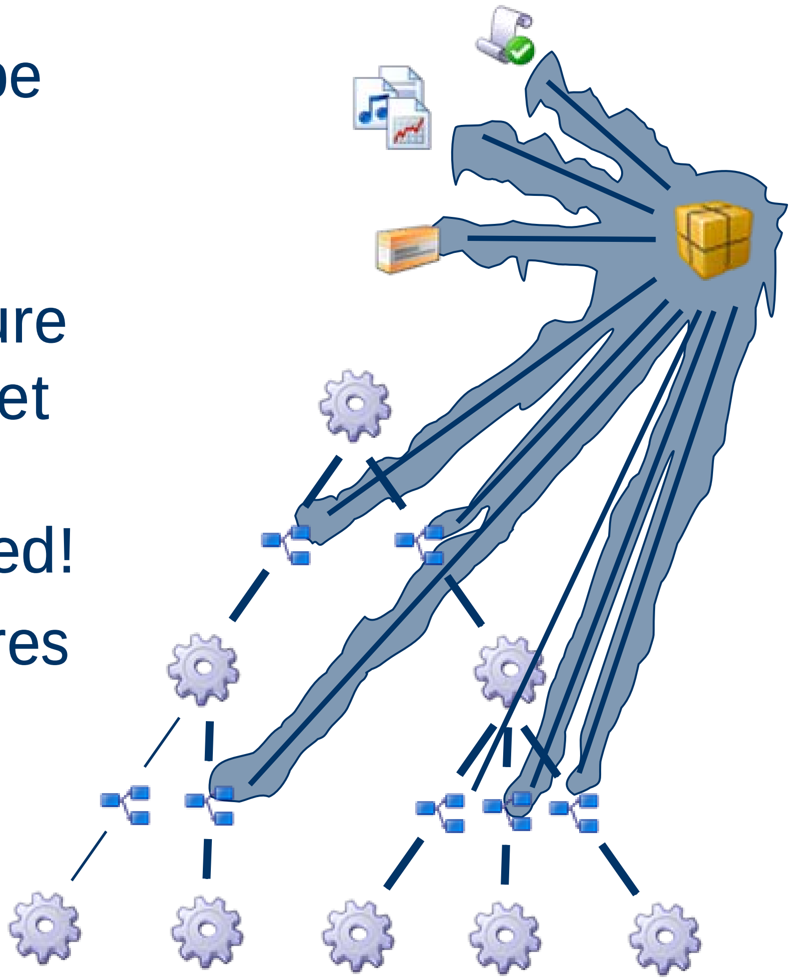
- The baseline object can explicitly point out the complete structure contained in a baseline

- Except baselining a structure, a baseline can contain all other business objects



Freezing a Baseline

- The content of a baseline can be edited but the history of it is always kept
- Baselines can be frozen to ensure that the specified information set can be re-called at all times. A frozen baseline can not be edited!
- Enables work on ‘open’ structures

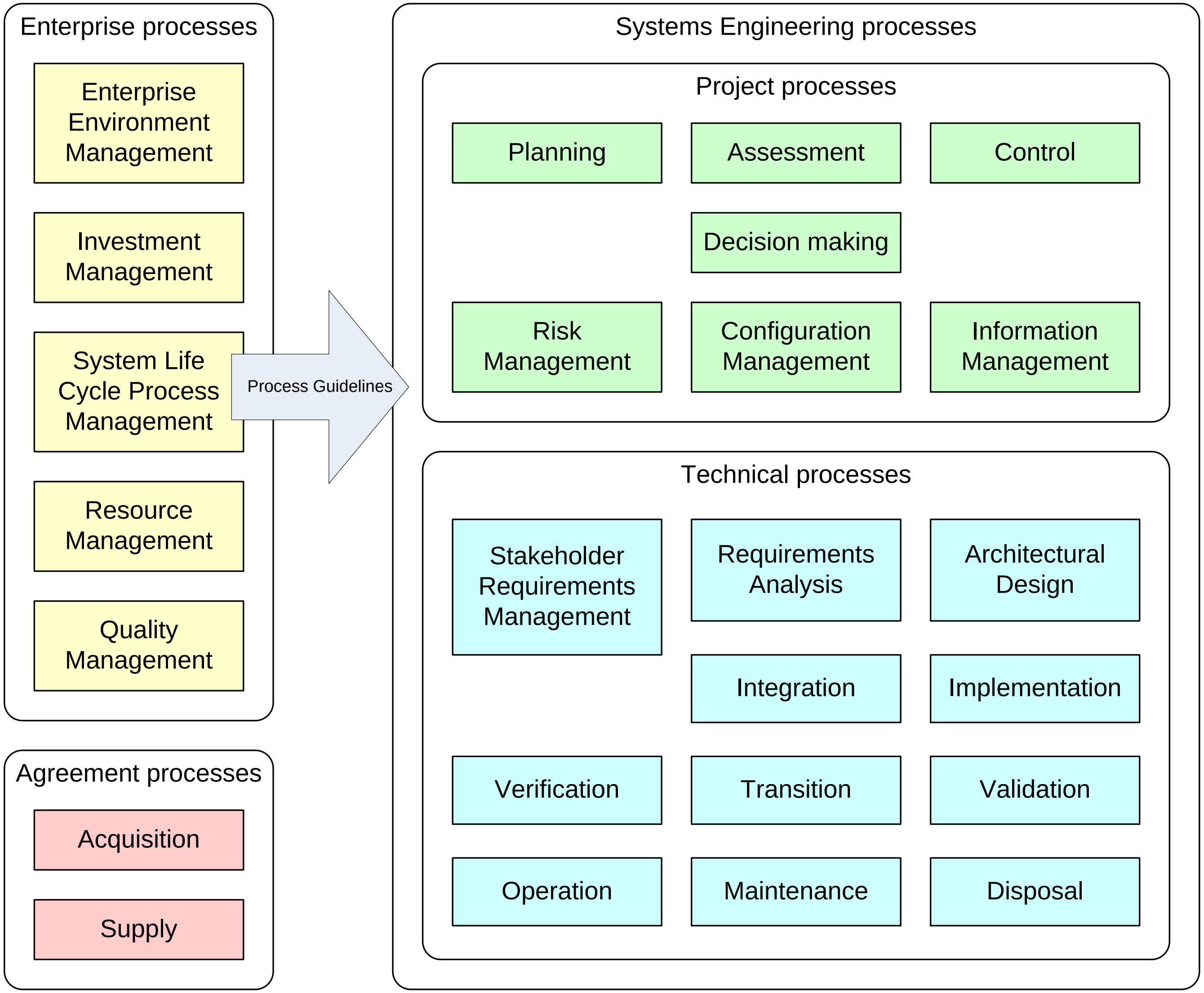


A Standard Approach to Change Management for SysML

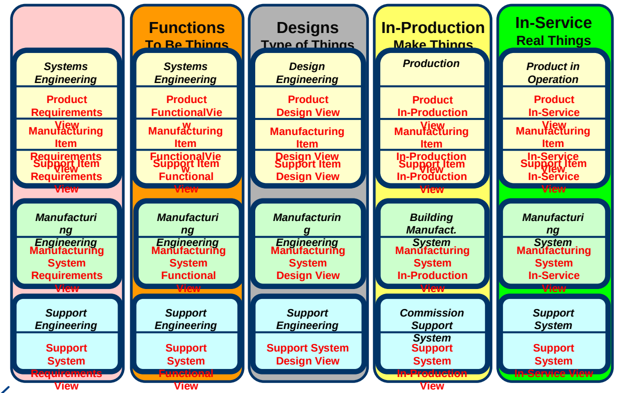
Extended Lifecycle Scope

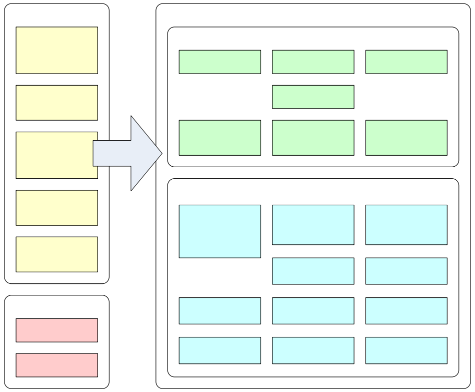
Requirements Need Things	Functions To Be Things	Designs Type of Things	In-Production Make Things	In-Service Real Things
Systems Engineering	*Systems Engineering*	*Design Engineering*	*Production*	*Product in Operation*
Product RequirementsView	Product FunctionalView	Product Design View	Product In-Production View	Product In-Service View
Manufacturing Item Requirements View	Manufacturing Item FunctionalView	Manufacturing Item Design View	Manufacturing Item In-Production View	Manufacturing Item In-Service View
Support Item Requirements View	Support Item Functional View	Support Item Design View	Support Item In-Production View	Support Item In-Service View
Manufacturing Engineering	*Manufacturing Engineering*	*Manufacturing Engineering*	*Building Manufact. System*	*Manufacturing System*
Manufacturing System Requirements View	Manufacturing System Functional View	Manufacturing System Design View	Manufacturing System In-Production View	Manufacturing System In-Service View
Support Engineering	*Support Engineering*	*Support Engineering*	*Commission Support System*	*Support System*
Support System Requirements View	Support System Functional View	Support System Design View	Support System In-Production View	Support System In-Service View

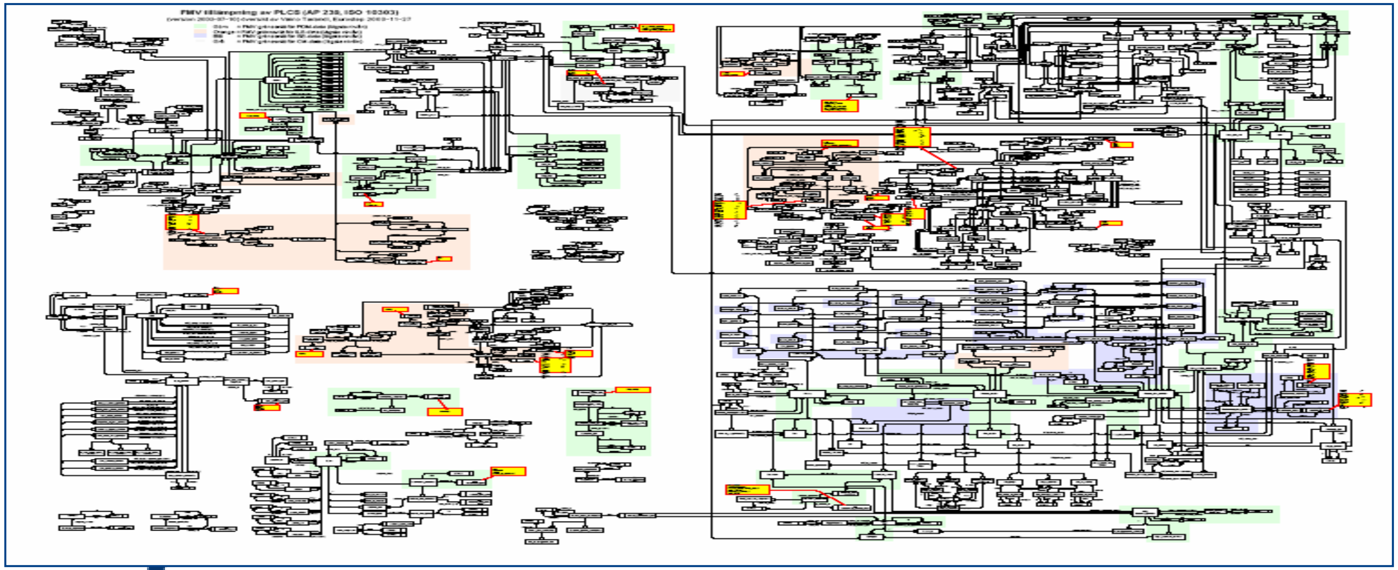
Full Process View



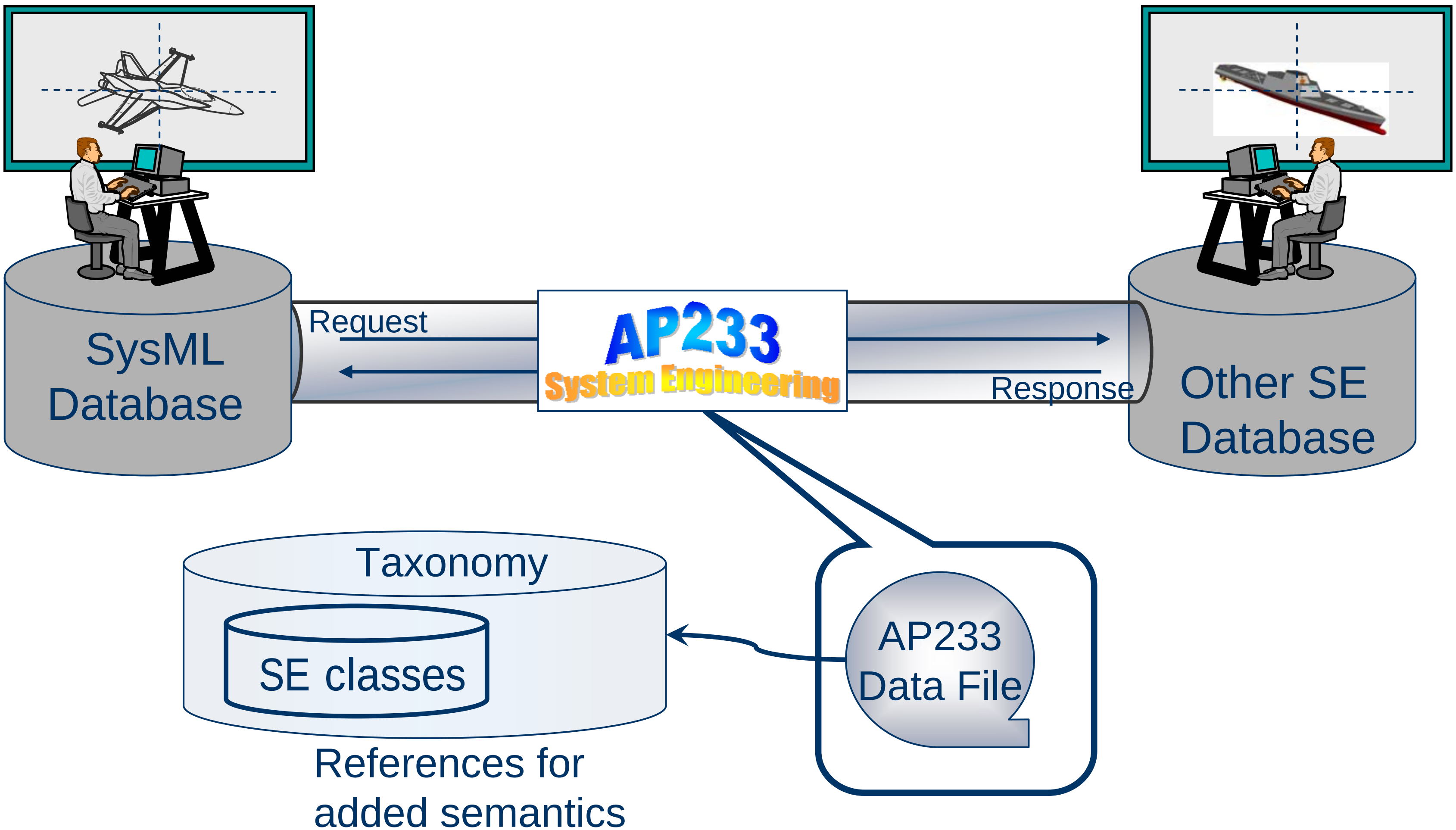
Integrated Information View







AP233 is a neutral SE information model



SysML-AP233 Alignment

- INCOSE drove much AP233 and SysML standardization
  - OMG for SysML
  - ISO TC184 SC4 Industrial Data for AP233

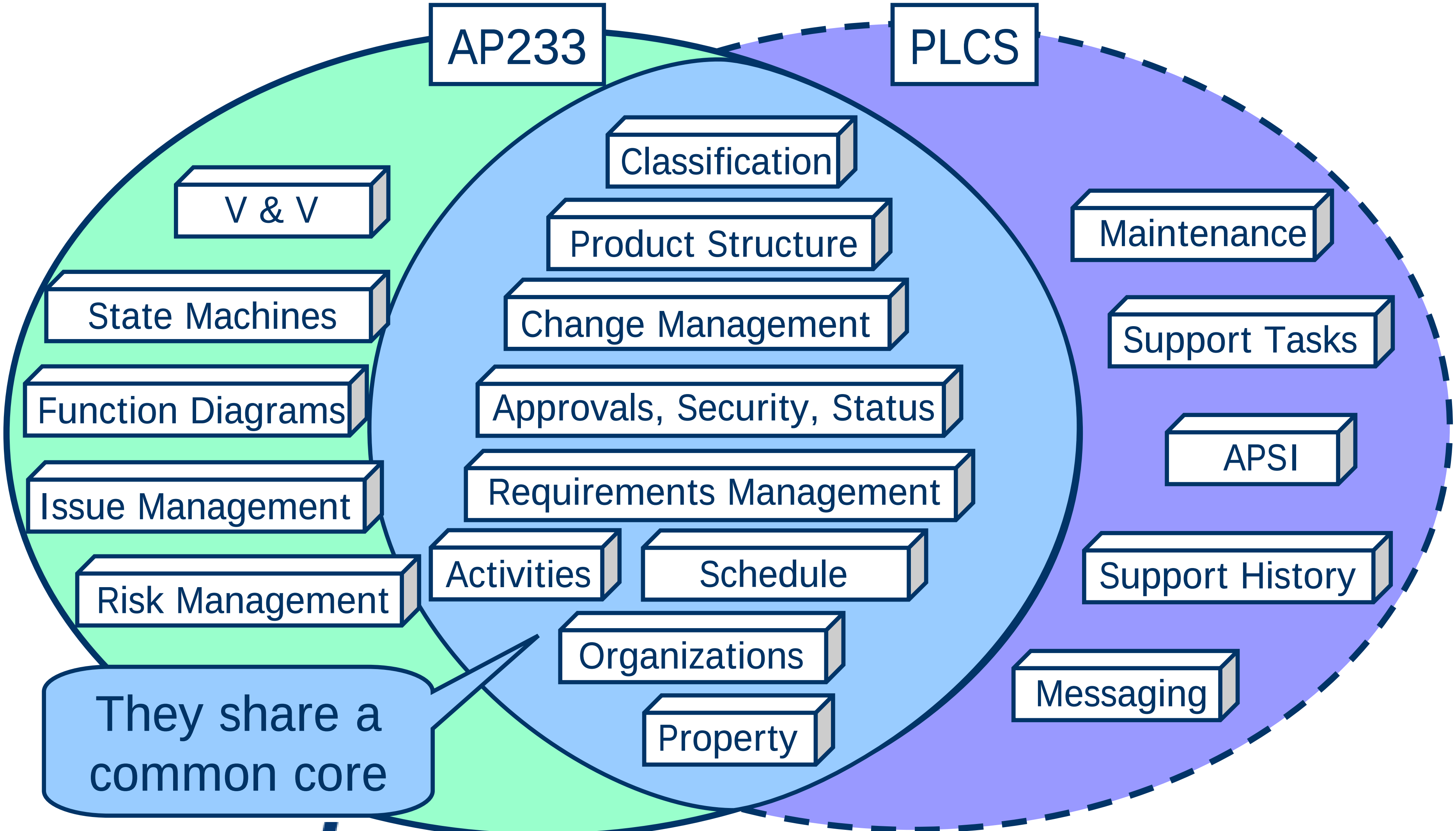
- AP233 and SysML teams worked together to align them

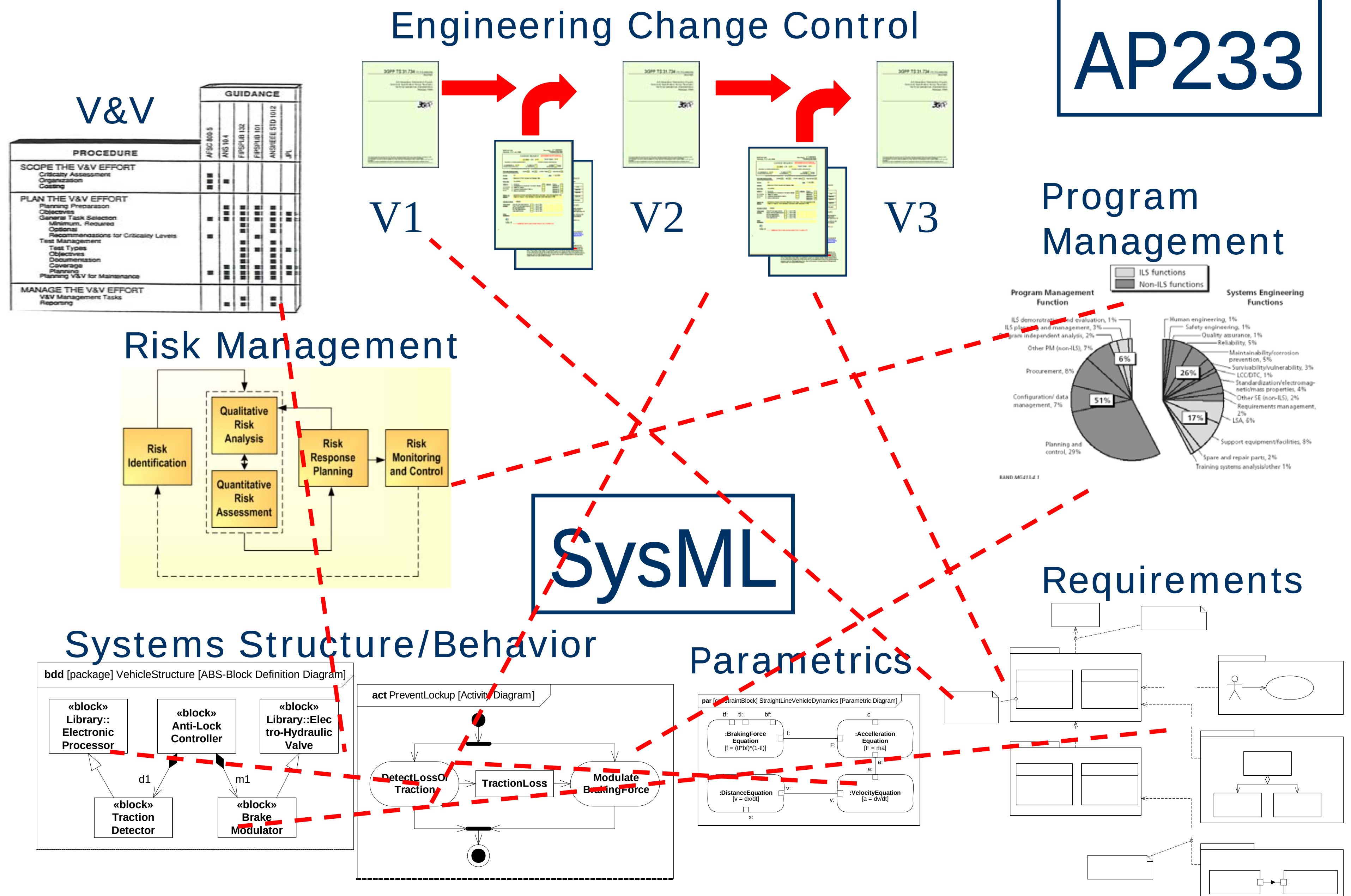
- Aims include
  - Align SysML and AP233 models
  - Provide meta-model mapping
  - Provisions for an independent public domain SysML/AP233 API
  - Set-up of data-exchange test-bed

SE Tool Plug-fest

- The SE Tool Interoperability Plug-Fest
  - SysML, AP233 and CADM testing capability from NIST and DoD's Systems and Software Engineering office
- Aims to support testing of SysML XMI and AP233 XML files
  - Just getting started
  - http://syseng.nist.gov/se-interop/plugfest/

AP233-PLCS Alignment





Engineering Change Control
AP233
V&V
GUIDANCE
PROCEDURE
SCOPE THE V&V EFFORT
PLAN THE V&V EFFORT
MANAGE THE V&V EFFORT
V1
V2
V3
Program Management
ILS functions
Non-ILS functions
Program Management Function
Systems Engineering Functions
Risk Management
Risk Identification
Qualitative Risk Analysis
Quantitative Risk Assessment
Risk Response Planning
Risk Monitoring and Control
SysML
Requirements
Systems Structure/Behavior
bdd [package] VehicleStructure [ABS-Block Definition Diagram]
«block» Library:: Electronic Processor
«block» Anti-Lock Controller
«block» Library::Electro-Hydraulic Valve
d1
m1
«block» Traction Detector
«block» Brake Modulator
act PreventLockup [Activity Diagram]
DetectLossOfTraction
TractionLoss
Modulate BrakingForce
Parametrics
par [constraintBlock] StraightLineVehicleDynamics [Parametric Diagram]
:BrakingForce Equation
[f = (tf*bf)*(1-tl)]
:Accelleration Equation
[F = ma]
:DistanceEquation
[v = dx/dt]
:VelocityEquation
[a = dv/dt]

eurostep

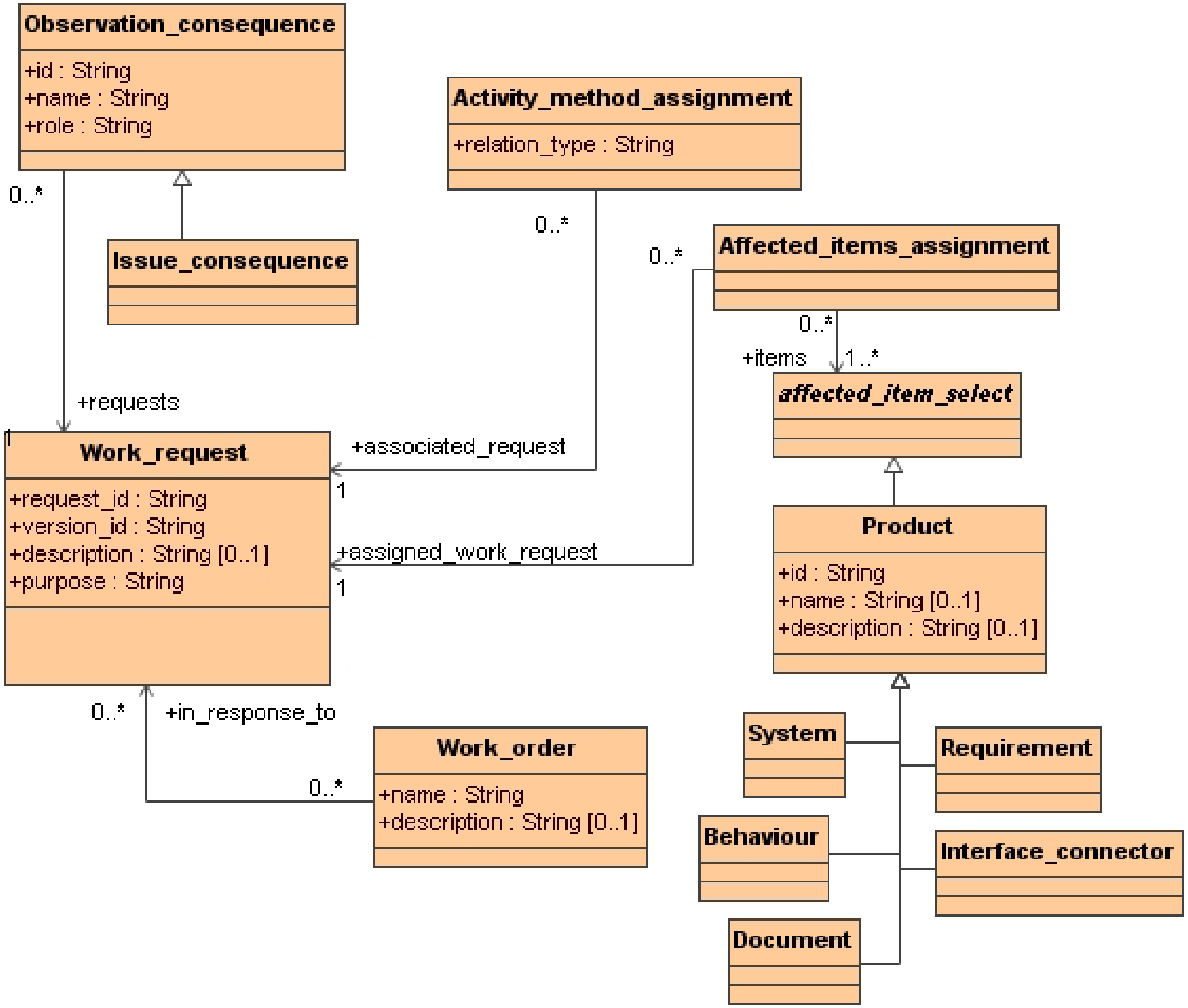
CM Items in AP233

- In AP233, the CM Item concept is represented as "Product" or any of its subclasses

- Specify SysML concepts that map to AP233 CM items

- Implement SysML/AP233 software
  - Convert the internal SysML data into A233 data maintaining reference to SysML data file itself
    - AP233 allows reference to any type of data file

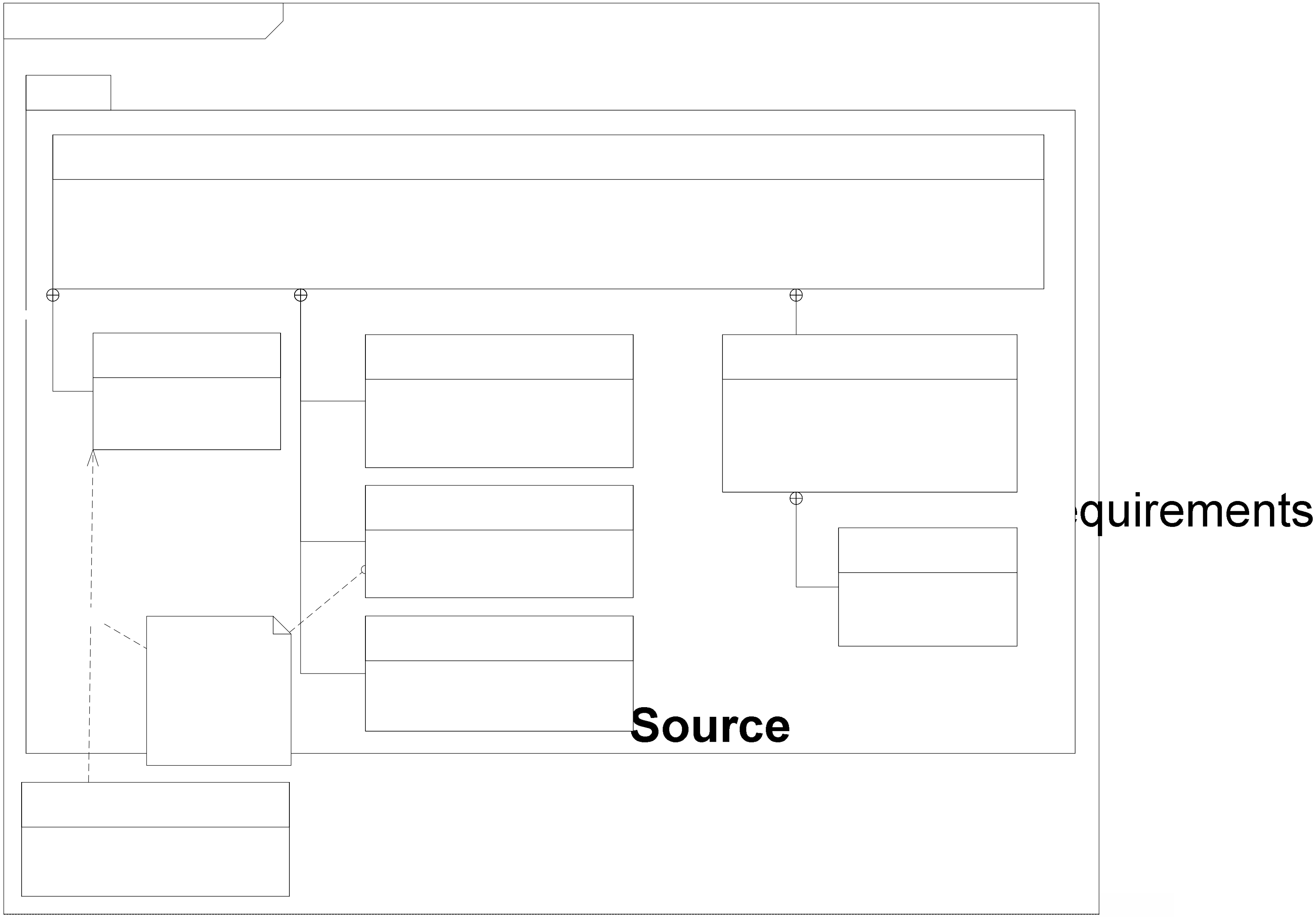
AP233 Change Management Schema



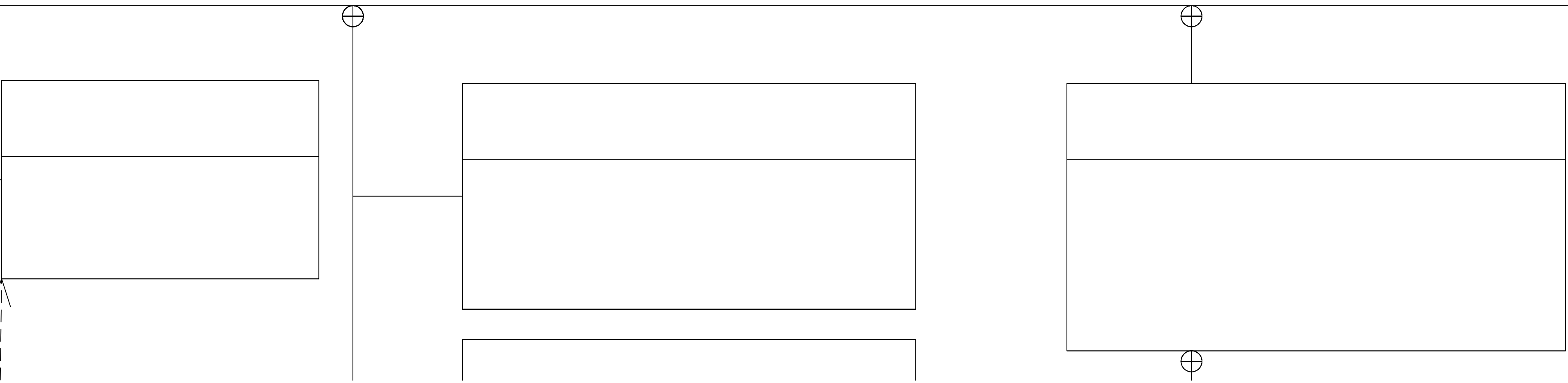
Use Change Management Tool

- In a tool that implements Engineering Change Management
  - Import AP233 data into Item, Item Version, etc.
  - Check-in the SysML data file itself
  - Create link between SysML data file and related Item
- Use CM Tool to manage Work Requests, Change Proposal and Change Order as describe earlier

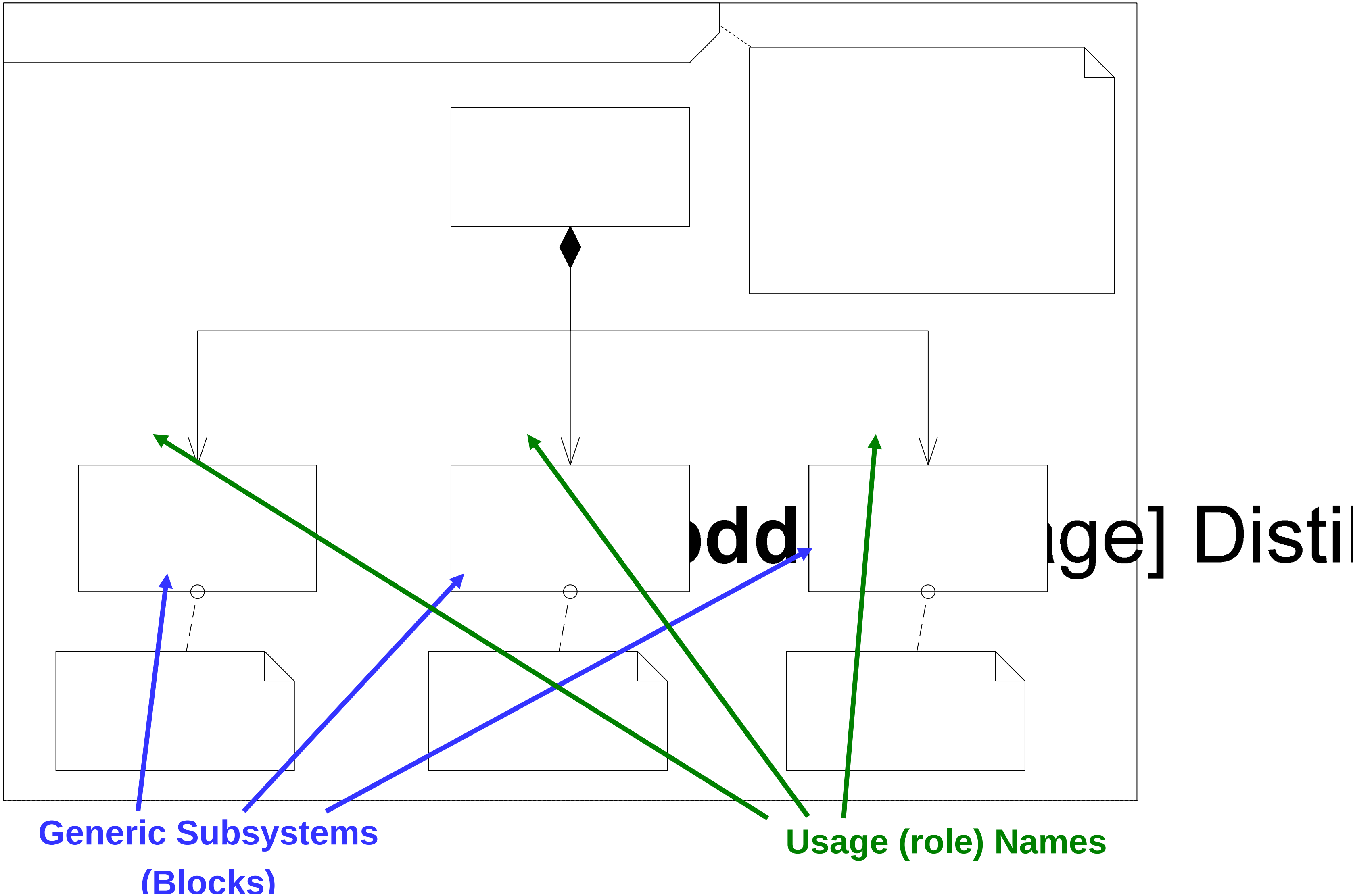
Example Requirements Diagram



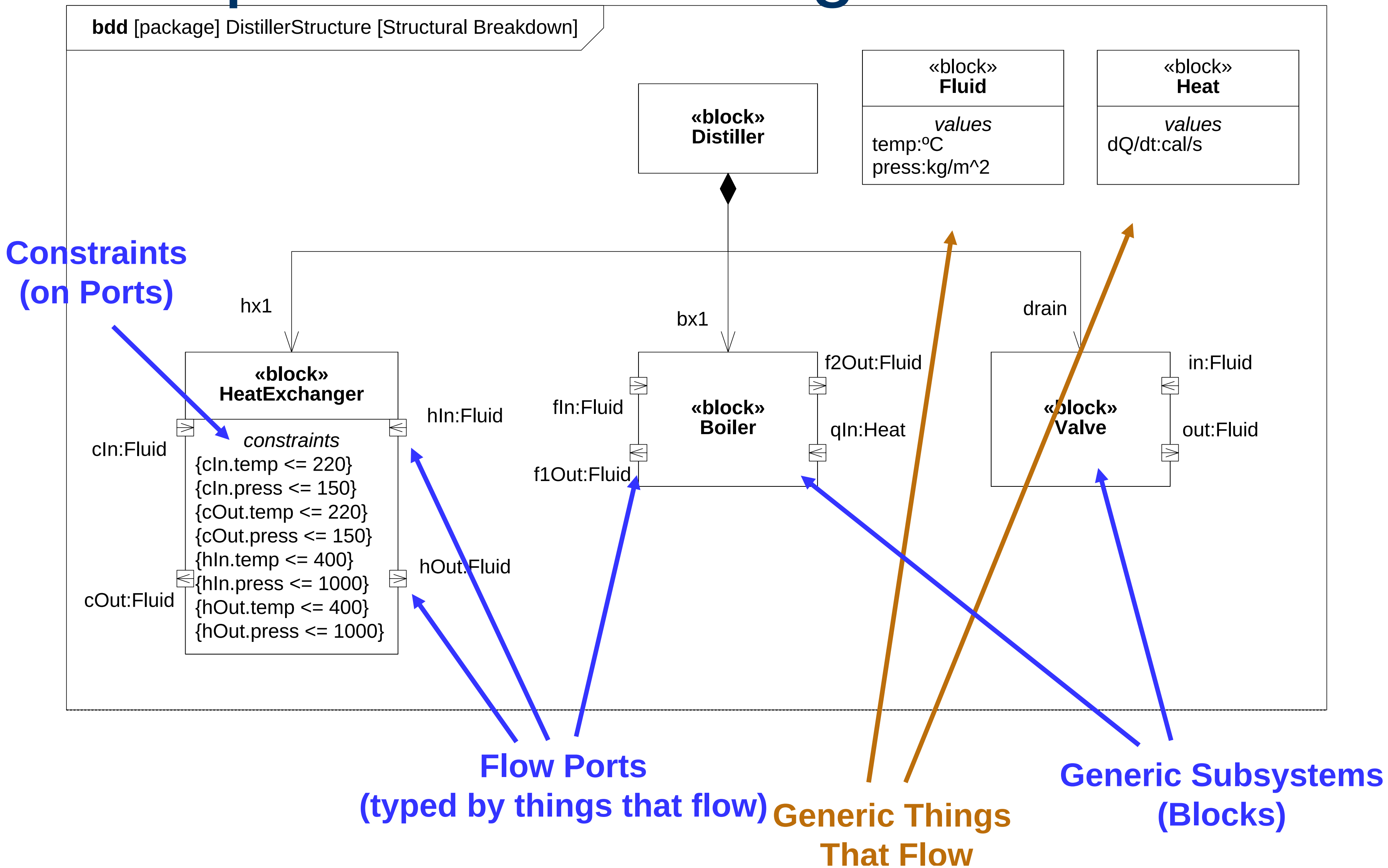
Zooming in on the Requirements



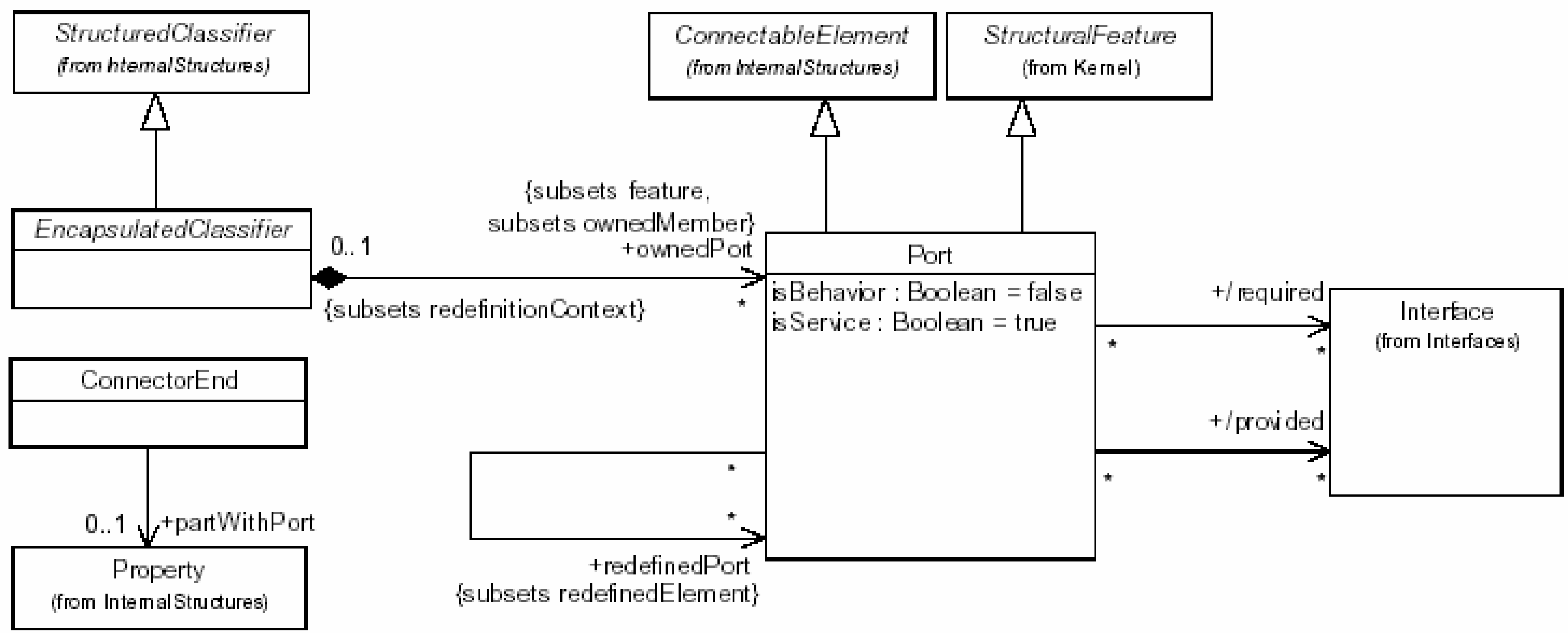
Example Block Definition Diagram



Example Heat Exchanger Flow Ports



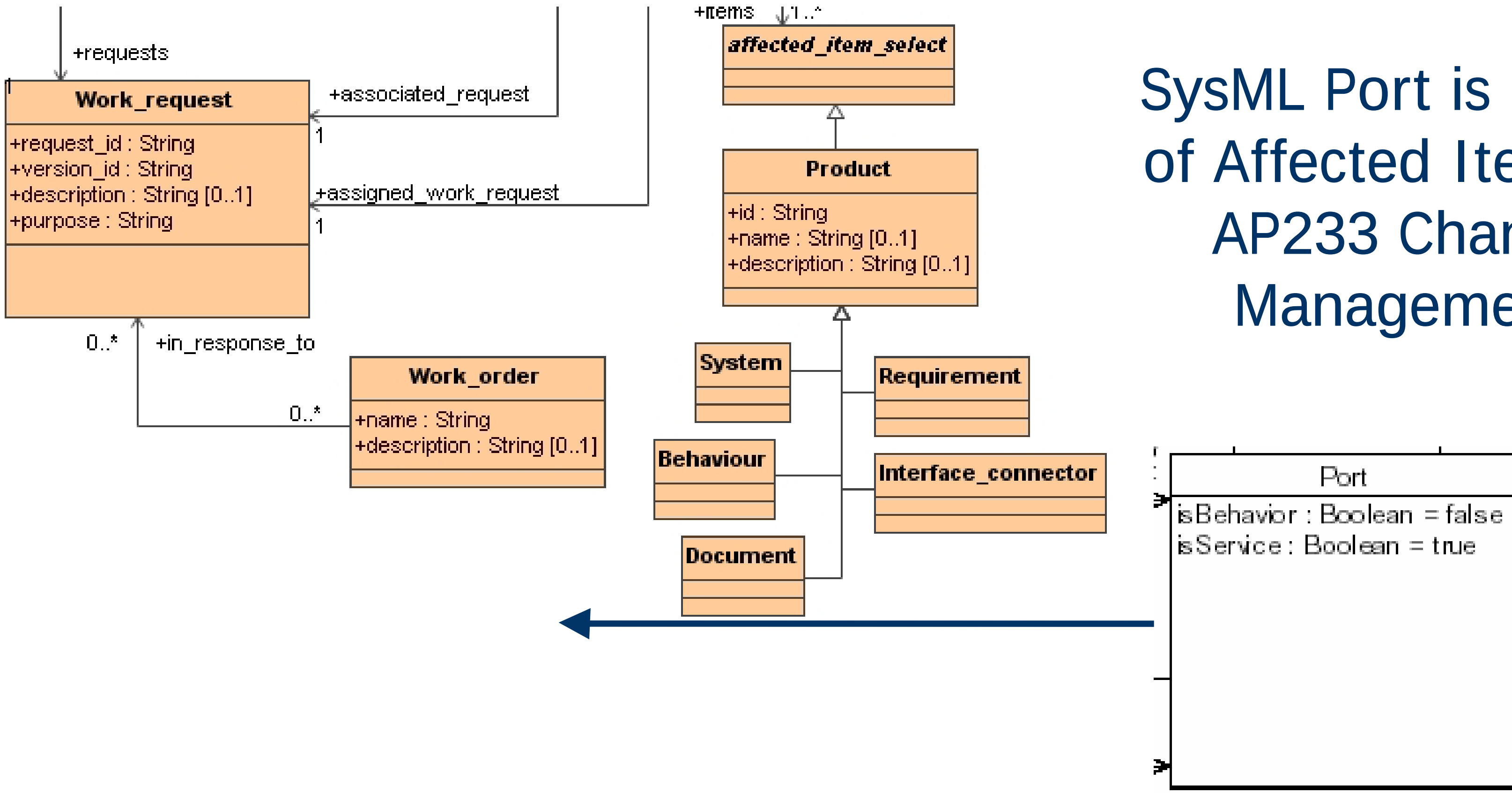
SysML Underlying Schema for Port



Initial SysML Map to AP233 CM Item

SysML Views	AP233 View
SysML Model	AP233 Document
SysML Package	AP233 System
SysML Block	AP233 System
SysML Requirement	AP233 Requirement
SysML State Machine	AP233 State Based Behaviour
SysML Ports	AP233 Interface Connector
SysML Use Case	AP233 Function Based Behaviour
SysML Problem	AP233 Work Request

Conceptually merge AP233/SysML



SysML Port is a kind of Affected Item for AP233 Change Management

Future integration approach

- ISO AP233 is modeled using the ISO EXPRESS information modeling language

- ISO EXPRESS being submitted to OMG for standardization, called MEXICO project

- Enables OMG Model Driven Architecture technologies to be applied to AP233 CM of SysML
  - Tight, direct, standardized AP233/SysML alignment

Issues for future work

- Working with multiple versions in SysML tools
- More work required on other SysML diagrams (e.g. Parametrics)
- Links between Items on diagrams and the SysML diagrams on which they appear in CM tools
- Feedback into SysML tools from CM tools

Conclusions

- ISO AP233 enables Engineering Change Management of significant aspects of SysML and other UML-based models
  - Brings more rigour to SE processes

- However, there’s still plenty of work to be done

- Proof-of-concept development underway using our Share-A-space product as collaboration and change management tool for MagicDraw SysML tool

AP233 References

- DODAF/AP233 project site
  – http://www.exff.org/ap233

- AP233 standards team site
  – http://www.ap233.org

- Eurostep
  – http://ap233.eurostep.com (kickoff Nov 07)
  – http://www.eurostep.com
  – http://www.share-a-space.com

Unifying Systems Engineering Simulations

-

Kevin Tang, Ryan O'Grady, Glenn Beach

Cybernet Systems Corporation, Ann Arbor, Michigan

Rakesh Patel, Jason Ueda

U.S. Army TARDEC, Warren, Michigan

Overview of Presentation

- Background
- Definition of Unified Simulation
- Real-life Example
  - Virtual Systems Integration Lab for U.S. Army
- Hurdles to Unified Simulation
- Conclusions
- Recommendations
- Q & A

Background

- The U.S. Department of Defense (DoD) relies on a multitude of fragmented simulations to assist in engineering new systems. The DoD recognizes the need for unified simulation environments to enhance the value of new models and help achieve its defense transformation goals; a major example of this is the U.S. Army's OneSAF program.
  - However, no plan exists to leverage the thousands of simulation models that remain idle on shelves.
  - Localized efforts by the government and its contractors to unify such models have been marginalized by a number of technical and non-technical hurdles, some of which are not obvious.
- Overall Goal: <u>Field the best systems for the future military force in the shortest time using the fewest resources.</u>

Definition of Unified Simulation

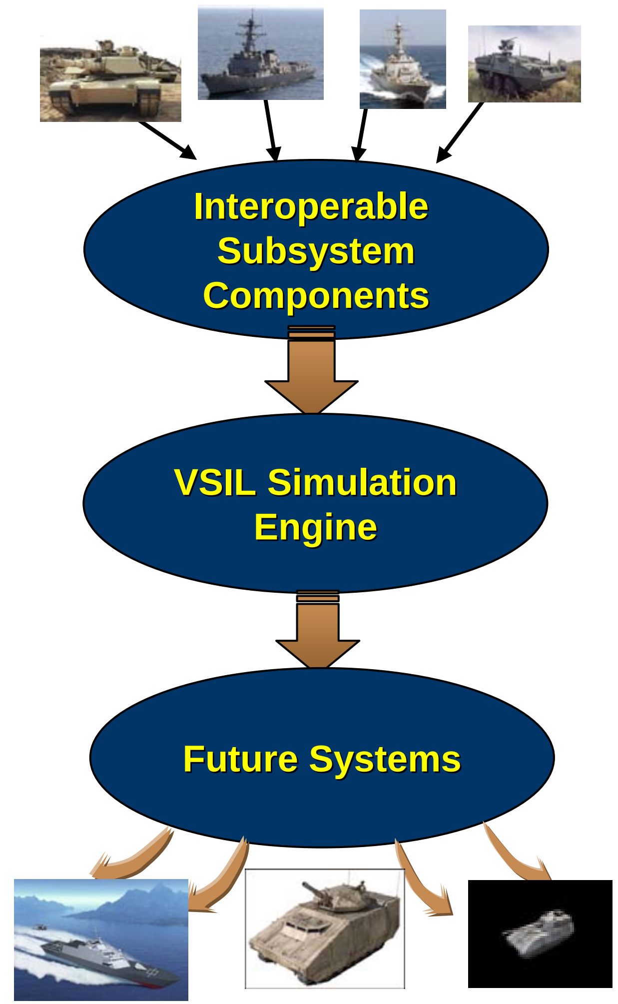
- Unified simulation is an ambitious goal for Systems Engineering that will be reached once the following criteria and capabilities are satisfied and delivered:
  – Interoperability standards allow any compliant simulation method to be incorporated (e.g., HLA, OneSAF)
  – All standalone simulation models can be integrated as pieces of a bigger puzzle (e.g., Matlab, Simulink, C++)
  – A global simulation picture provides the ability to “zoom in” on any level of detail ranging from systems to sub-components
  – System design feedback gets generated that accelerates feasibility testing of hardware and software

Real-life Example

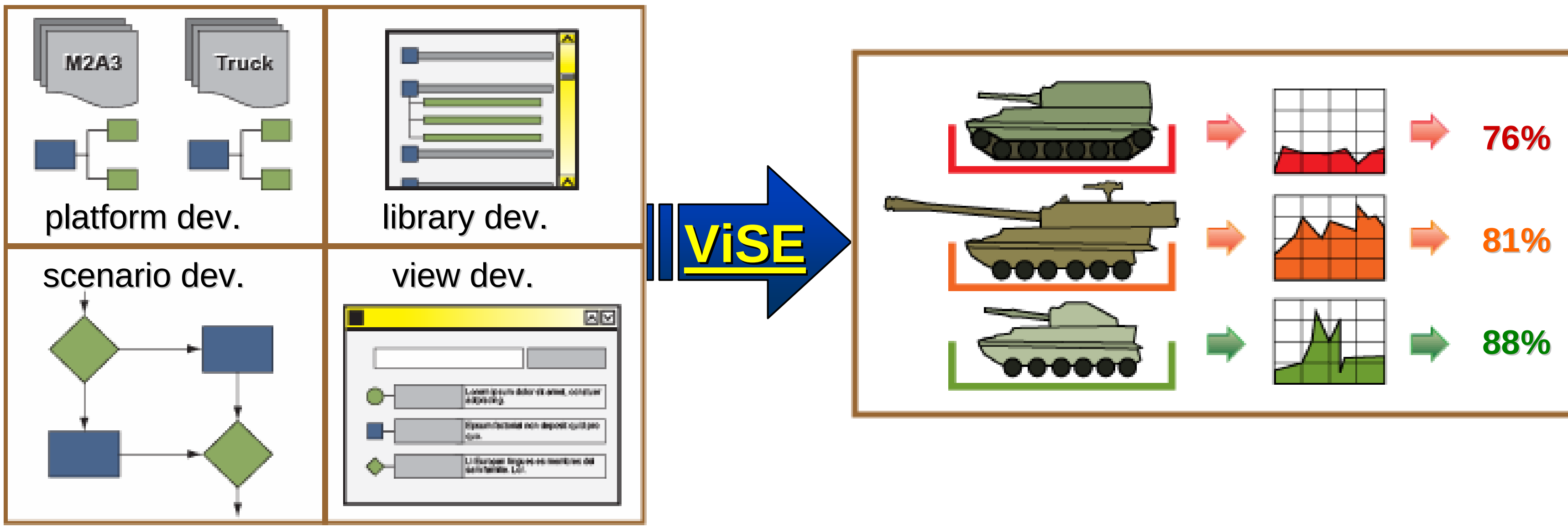
- Virtual System Integration Lab (VSIL) for the U.S. Army Tank Automotive Research, Development & Engineering Center (TARDEC)
  - VSIL is a simulation suite for accelerating systems engineering
  - Tests prototype designs prior to committing to a physical prototype

VSIL Objectives

- Enhance next-generation vehicle design and development
- Improve efficiency of simulation development
- Perform cost-benefit analysis on component models up to full deployments
- Transform development process so that new vehicle designs benefit from the development of all previous vehicles

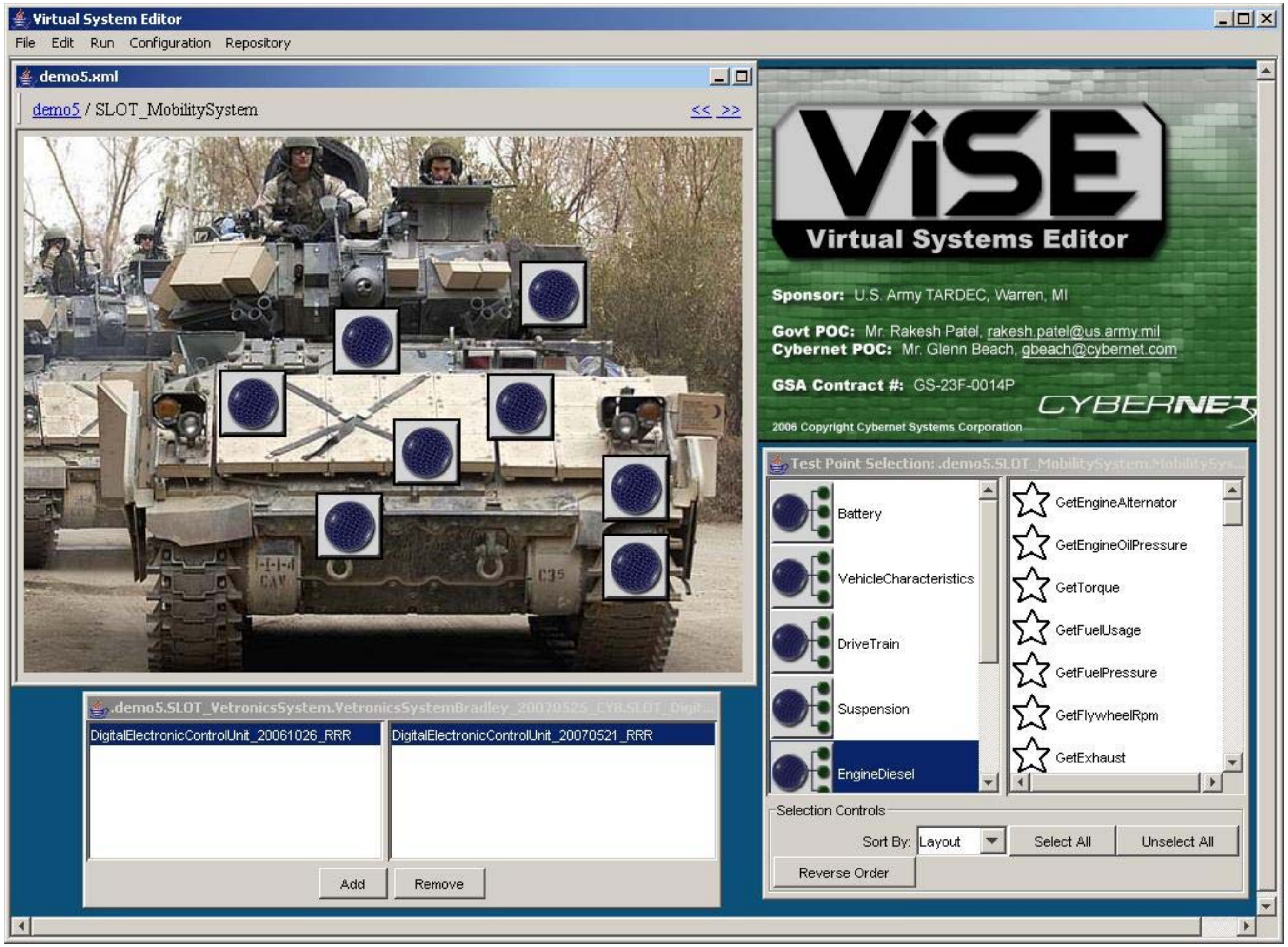


Result: Virtual Systems Editing



- Through the Virtual Systems Editor (ViSE), VSIL provides an integrated design, development, and simulation toolset to enable automated component trade-off analysis and requirements generation

ViSE Version 0.5



Hurdles to Unified Simulation

- The VSIL team encountered the following hurdles during its joint simulation efforts with TARDEC:
  – The availability of models
  – The usability of simulation construction tools
  – The creation of reference architecture
  – The complexity of simulation results
  – The automation of repetitive integration tasks
  – The verification & validation of component models

Hurdles Explained

- The availability of models
  - Credibility of M&S is tied to the availability and fidelity of component models of interest (e.g., Mobility, Suspension)
  - Populating a useful model library from scratch is a lengthy task that requires vast domain expertise
- The creation of Reference Architecture (RA)
  - RA defines interfaces required by models to be leveraged into a unified simulation (e.g., RA for vehicle electronics component)
  - Creating RA is an exhausting task. A mature RA requires constant re-factoring over time.

Hurdles Explained

- The verification & validation of simulation models
  - True validation of models is only possible by using real data taken from the component or system being modeled, or by using the most high-fidelity models available
  - Requires definitions for “high-fidelity” models and tiers of model fidelity
- The complexity of simulation and results
  - Need better analysis tools to process output data faster
  - Takes more time to execute simulations – the cost of accuracy

Hurdles Explained

- The usability of simulation construction tools
  – Impacts the efficiency of model verification & validation
  – User-friendly tools encourage more use, reduces anxiety, and builds confidence
- The automation of repetitive integration & analysis tasks
  – Automated model wrapping for common formats is highly desired
  – Need to automate the formatting and analysis of output data

Conclusions for Military Simulation

- Simulation-based engineering is a vital but expensive enterprise.
- Unified simulation is an ambitious goal that will accelerate innovation and make systems engineering more viable in the long run.
- Govt. leadership will help overcome the hurdles to unifying military systems engineering simulations.
- The DoD is the only organization that can truly unify systems engineering simulations for military use. Relying solely on industry and non-profits like SISO to accomplish the task will not achieve this goal in the long term without Govt. mandate.

Recommendations to Maximize Simulation Reuse across DoD

- To establish a unified approach to maximize simulation reuse, the DoD needs to mandate a standard response from industry. The DoD's mandate must include provisions for three broad areas:
  - 1. Model Sufficiency
    - Are high-fidelity models available?
    - Are they compliant with interoperability standards?
  - 2. Tool Usability
    - Need tools that highly automate the M&S process
    - Software tools must be easy to use, easy to learn, and fast
  - 3. Process Adoption
    - Need usage to get credibility and continuous improvement
    - Write model deliverables into contracts
    - Make model repositories easily searchable

Recommendations to Maximize Simulation Reuse across DoD

- Mandate wider deployments of existing efforts. The adoption of simulation-based processes and toolsets in the defense space will gain the most traction when mandated with ongoing efforts.
  - For example, existing programs such as OneSAF should publish their plan how they will interoperate with new models. The next evolution of OneSAF should incorporate higher fidelity simulations of FCS models, which may already exist.
  - Since OneSAF is expected to be a platform for other services if it continues to be successful, this should trigger a number of action items including: discovering needed models, identifying interoperability protocols, and designing necessary extensions to incorporate OneSAF into new programs.

Recommendations to Maximize Simulation Reuse across DoD

- Employ a bottom-up approach to unifying simulations.
  - Experience shows that a bottom-up approach to unifying simulations is superior to a top-down approach.
  - For example, the expansive JSIM project that preceded OneSAF failed due to the management burdens of operating as a joint-service project.
- Account for ongoing simulation interoperability efforts.
  - A unified approach relies on simulation interoperability.
  - Consider how ongoing infrastructure developments in the DoD community will fit in, including HLA, BOMS, SEDRIS, and MSDL.
- Populate government-owned model repositories. Let industry maintain proprietary repositories with interface-based model access.
  - Interface with decentralized repositories based on service agreements
  - Provide real data for Govt. engineers and support contractors to use

Recommendations to Maximize Simulation Reuse across DoD

- Establish a validation program for simulation models.
  - A program is necessary to verify the adequacy of simulation models.
  - Can be run by a university center, similar to the way Johns Hopkins was contracted to perform HLA RTI compliance testing.
- Invest in a standard simulation design environment.
  - Investing in a standard simulation design environment will enable the DoD to send a tangible mandate to its PEOs and contractors.
  - Identify a software toolset that is easy to use, accurate, useful, & flexible.
- Require the delivery of component models developed under contract.
  - Govt. & Industry need standardized tools to handoff and evaluate models
  - The DoD needs more automated M&S capabilities and should buy better tools to effectively manage M&S.

Question & Answer

- Please address questions after the conference to Kevin Tang:
  `ktang@cybernet.com`

Lessons Learned in Seamless Integration of CMMI, TSP, and PSP

Why All Three Are Needed

10th Annual Systems Engineering Conference

October 24, 2007

ais

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http://www.sei.cmu.edu/managing/ieee-award/ieee.award.html

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  - Quality and Schedule
  - Rational Management and Commitment
  - Insanity and Malpractice
- Three Improvement Perspectives
  - Organization - CMM/CMMI
  - Individual – PSP
  - Team – TSP
- Seamless Integration of CMMI, PSP, TSP
  - The glue – Process Improvement Proposal
  - AIS Experience
- Lessons Learned

Quality Is More Important Than Schedule

"In today's software marketplace, the principal focus is on cost, schedule, and function; quality is lost in the noise. This is unfortunate since poor quality performance is the root cause of most software cost and schedule problems."

Watts Humphrey

Rational Management - Developers

- When pressed for early deliveries, the responsible team members say

  “I understand your requirements, I will do my utmost to meet it, but until I make a plan, I can not responsibly commit to a date”

ais

Rational Management - Managers

- When pressed for early deliveries, the responsible managers say

> “I trust you to create an aggressive and realistic plan, I will review the plan, but I will not commit you to a date that you can not meet”

Rational Management - Principles

- Set challenging goals
- Get the facts
- Use facts and data
- Anticipate and address problems

Insanity or Malpractice?

Insanity

Doing the same thing over and over and expecting a different result

Malpractice

An organization which does not have a top-management-sponsored continuous improvement initiative in place

ais

Organization Improvement Capability Maturity Model

Level	Focus	Key Process Areas (KPA)
5 Optimizing	Continuous process improvement	Defect prevention Technology change management Process change management
4 Managed	Product and process quality	Quantitative process management Software quality management
3 Defined	Engineering process	Organization process focus Organization process definition Training program Integrated software management Software product engineering Intergroup coordination Peer reviews
2 Repeatable	Project management	Requirements management Software project planning Software project tracking Software quality assurance Software configuration management Software subcontract management

Comparing SW-CMM to CMMI

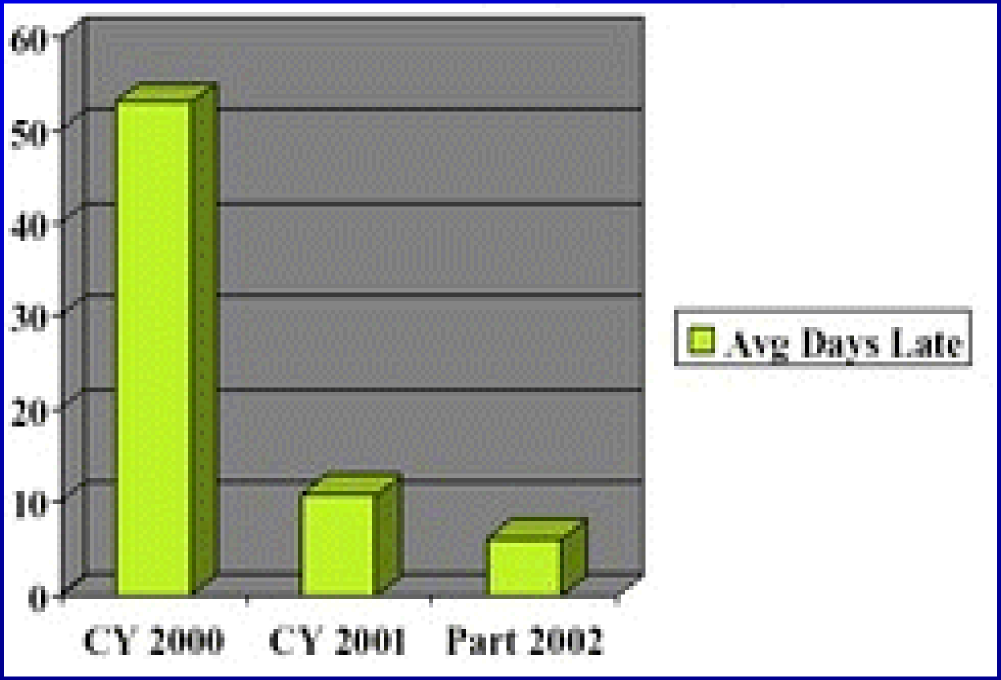
	SW-CMM key process areas	CMMI Process Areas
Level 5 *Optimizing*	Defect Prevention Technology Change Management Process Change Management	Causal Analysis and Resolution Organizational Innovation and Deployment
Level 4 *Managed*	Quantitative Process Management Software Quality Management	Organizational Process Performance Quantitative Project Management
Level 3 *Defined*	Organization Process Focus Organization Process Definition Training Program Integrated Software Management Software Product Engineering Intergroup Coordination Peer Reviews	Organizational Process Focus Organizational Process Definition Organizational Training Integrated Project Management Risk Management Requirements Development Technical Solution Product Integration Verification Validation Decision Analysis and Resolution
Level 2 *Repeatable*	Requirements Mgmt Software Project Planning Software Project Tracking & Oversight Software Subcontractor Management Software Quality Assurance Software Configuration Management	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Product & Process Quality Assurance Configuration Management Measurement and Analysis

Issues Addressed by CMM

- Getting management attention
- Maintaining long-term improvement focus
- Guiding the improvement work

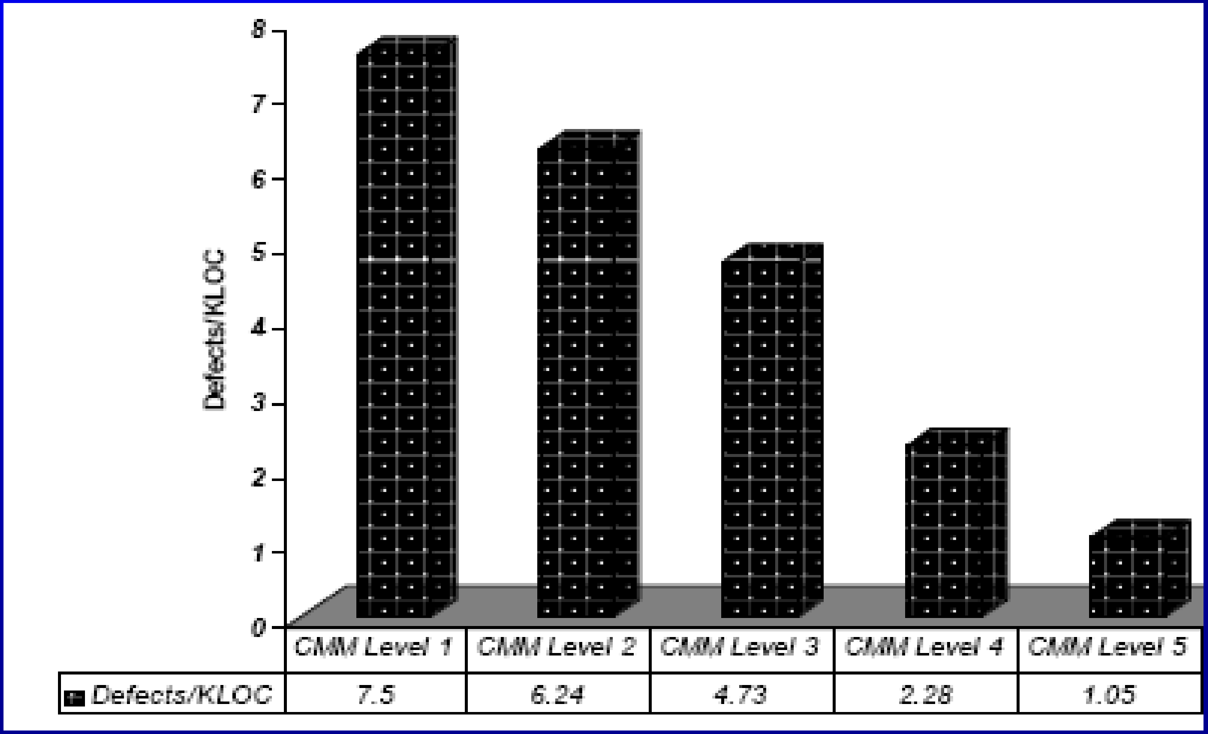
CMM Results – Schedule GM

- Average number of days late in meeting milestones declined from over 50 days to fewer than 10 following organization focus on CMMI



General Motors Presentation, SEPG, Boston, MA, 2003

CMM Results – Defects



The TSP in Practice, SEI Technical Report, September 2003

CMM Problems

- No simple model could precisely measure process maturity and complex models are not useful in guiding improvement
- CMM consciously focused on *what* organization should do, not on *how* they should do it
- The teamwork practices and personal disciplines required for quality software work are almost entirely issues of *how*, and not just *what*
- Because engineers will not change the way they work without very specific guidance, the CMM does not change engineering behavior

ais

The Real Need

- The need is not for lots of process data but for engineers who gather and use that data
- What would happen if software professionals used sound engineering practices?
  - made and followed detailed plans
  - gathered and used historical data
  - measured and managed quality
  - analyzed and improved their processes
- The need is for a Level 5 Process at the individual level

Self Improvement From Project To Project

"You can not stand still, so you should treat every project as a way to build talent rather than merely treating your talent as a way to build projects"

Watts Humphrey

Self Improvement
Personal Software Process - 1

Team Software Process
Requirements
Configuration management

PSP3
Cyclic development

scaling up PSP methods to larger projects

PSP2
Code reviews
Design reviews

PSP2.1
Design templates

defect and yield management

PSP1
Size estimating
Test report

PSP1.1
Task planning
Schedule planning

size, resource, and schedule plans

PSP0
Current process
Time recording
Defect recording
Defect type standard

PSP0.1
Coding standard
Size measurement
Process improvement proposal (PIP)

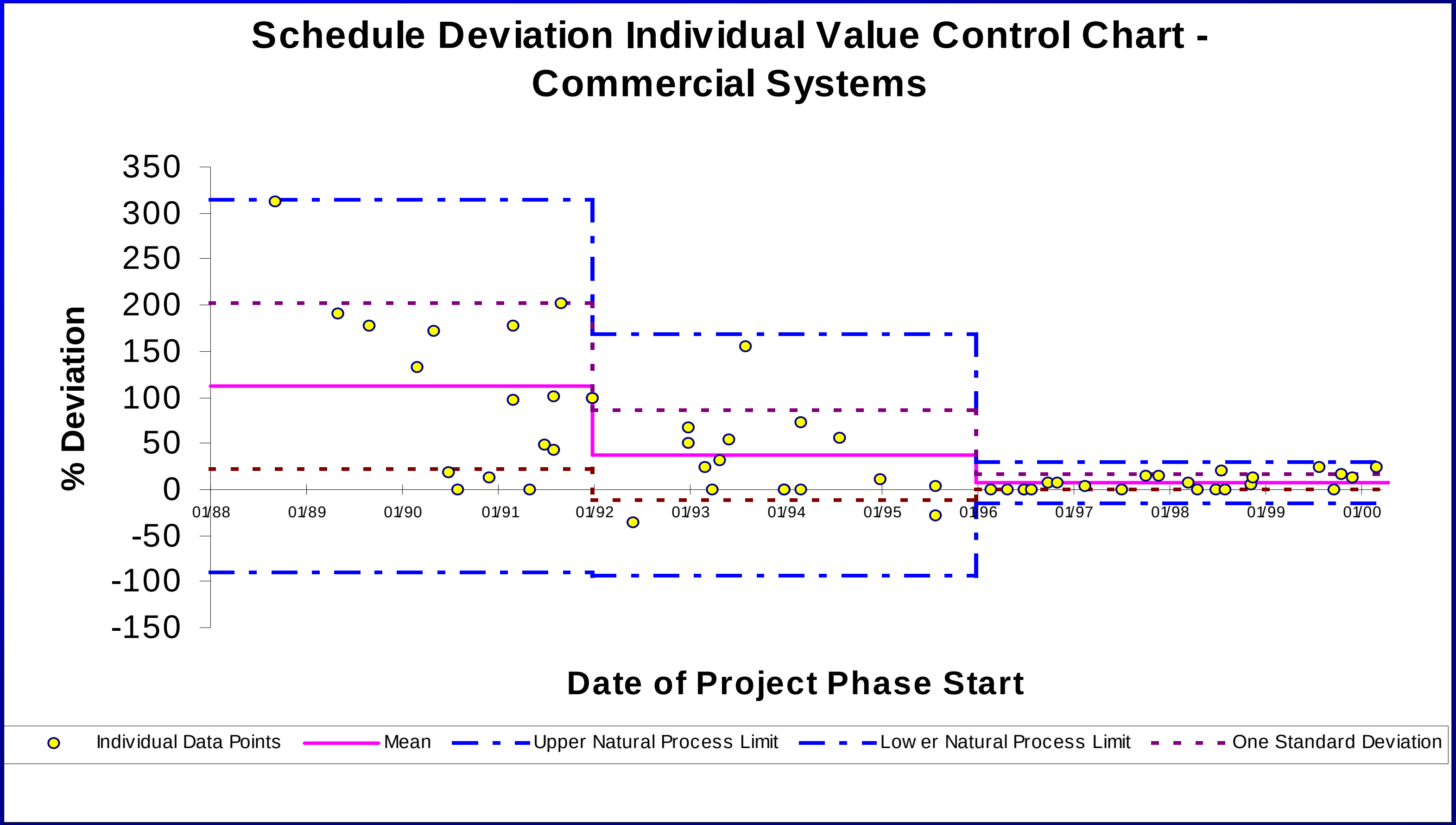
establishing a measured performance baseline

Source: Software Engineering Institute

Self Improvement
Personal Software Process -2

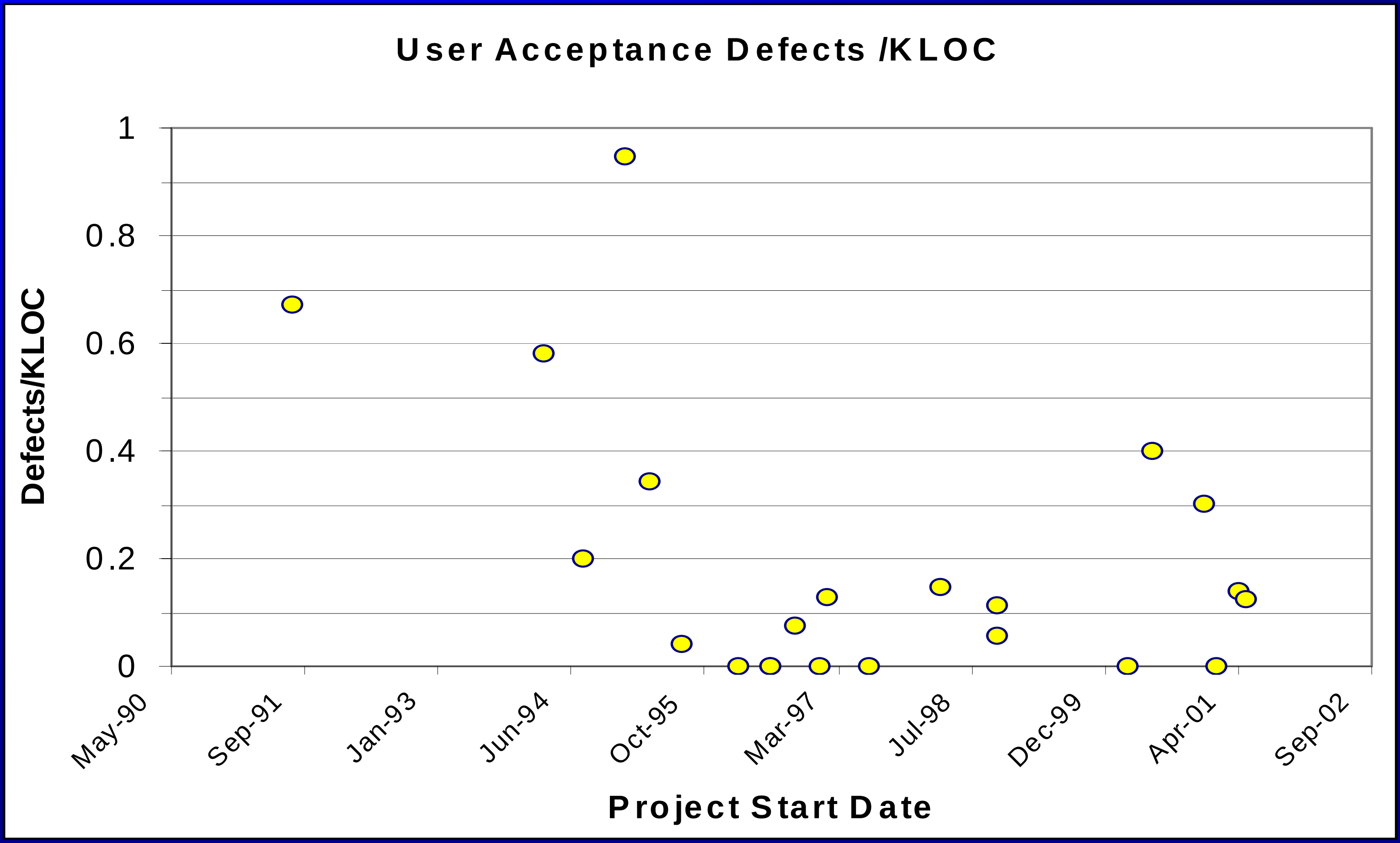
- At the end of the PSP training, developers know how to:
  - Consistently gather size, time, and defect data
  - Make commitments based on historical data
  - Analyze personal data to answer questions
    - Where am I spending my time?
    - What are my common defects?
    - Where do I inject the defects?
    - What goals do I need to set to improve?

PSP Results – Schedule AIS



ais

PSP Results – Defects AIS



PSP Problems

- To do quality work, engineers need a detailed plan and a defined process
- Without the process, they cannot make detailed plans, take consistent measurements, or track their work against the plan
- However, when engineers have a project to deliver, they are rarely willing to take the time to define a complex process, even when they know how

The Real Need

- Need a mechanism to guide teams through defining their processes and making complete, precise, and detailed plans

- Need a vehicle to help organizations capitalize on the potential benefits of disciplined teamwork

Team Improvement
Jelled Teams

“The speed with which organizations form and deploy teams is the single most important factor in determining their competitive success”

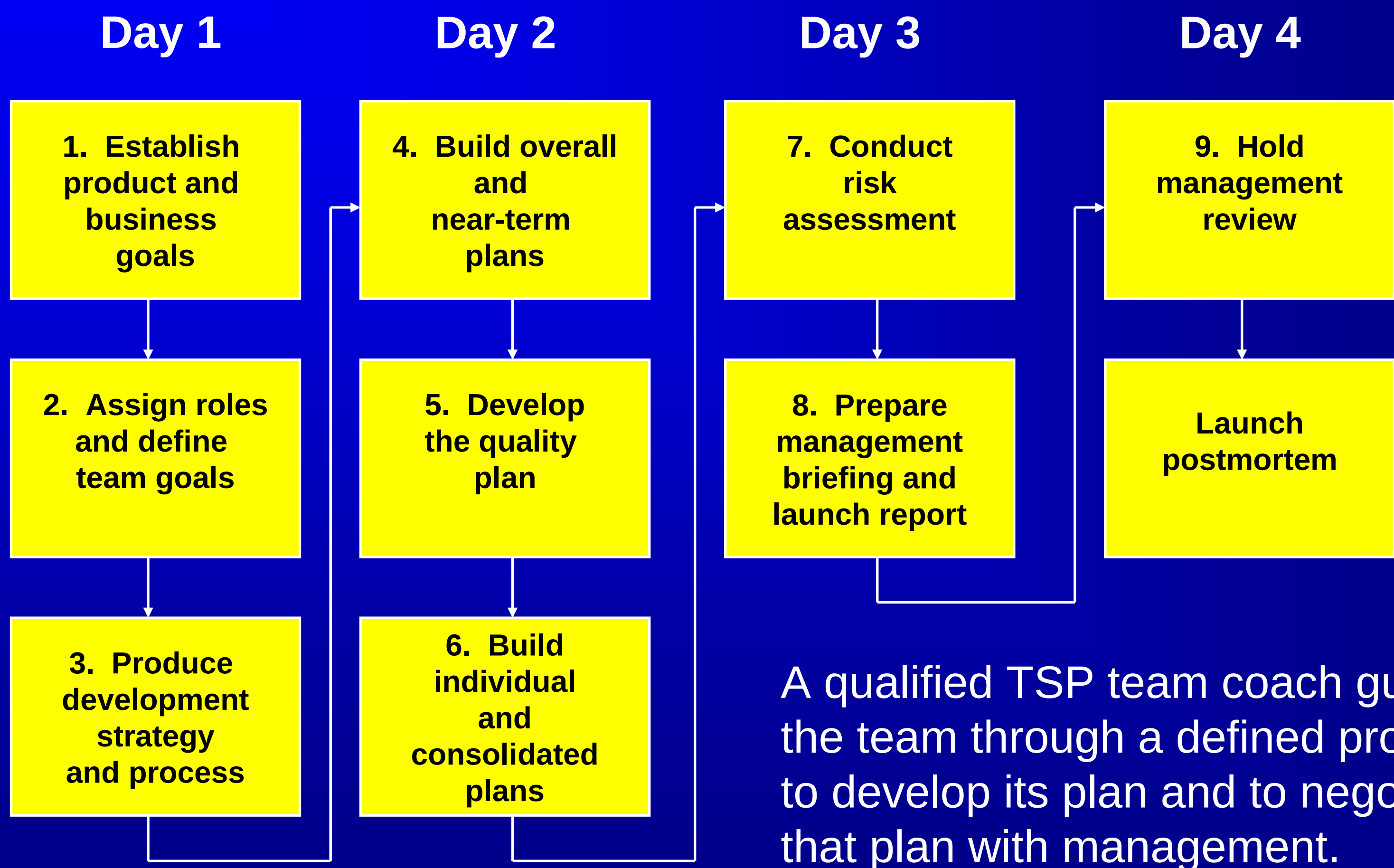
“Jelled teams are the most powerful tool ever devised for doing challenging work”

Watts Humphrey

Team Improvement
Self-directed Teams

- Characteristics of self-directed teams
  - Sense of membership and belonging
  - Commitment to a common team goal
  - Ownership of the process and plan
  - The skill to make a plan, the conviction to defend it, and the discipline to follow it
  - Dedication to excellence

Building Self-directed Teams
The TSP Launch Process



A qualified TSP team coach guides the team through a defined process to develop its plan and to negotiate that plan with management.

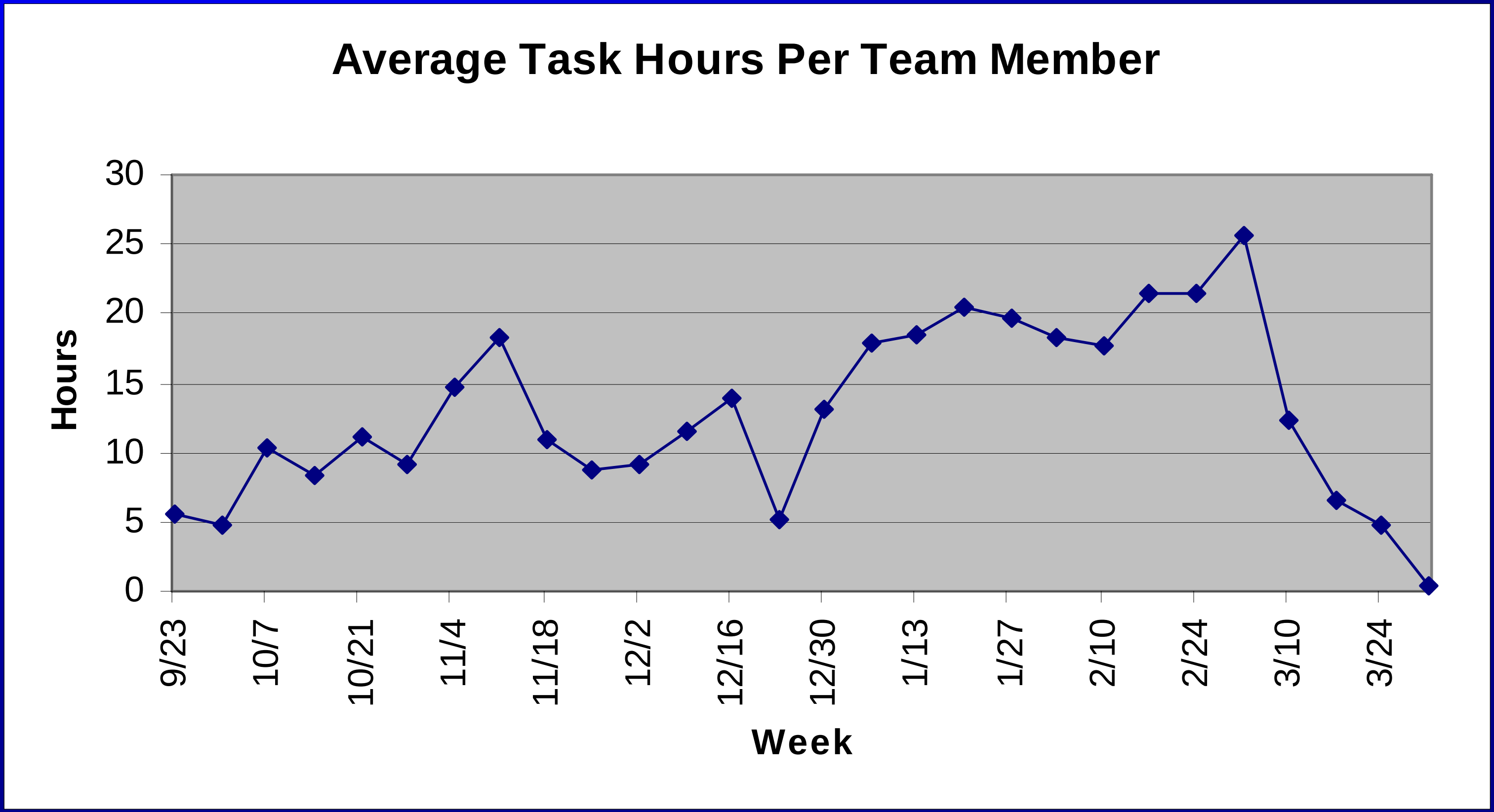
Self-directed Teams
Project Tracking Issues - 1

- With PSP training, developers know how to plan, schedule, and track their work
- TSP teams use these PSP-learned methods to make detailed plans
  - Tasks are no more than 10 task hours each
  - Task time is recorded daily
  - EV is measured weekly
- You can tell project status to within 10 task hours
- TSP teams regularly report their status

Self-directed Teams
Project Tracking Issues - 2

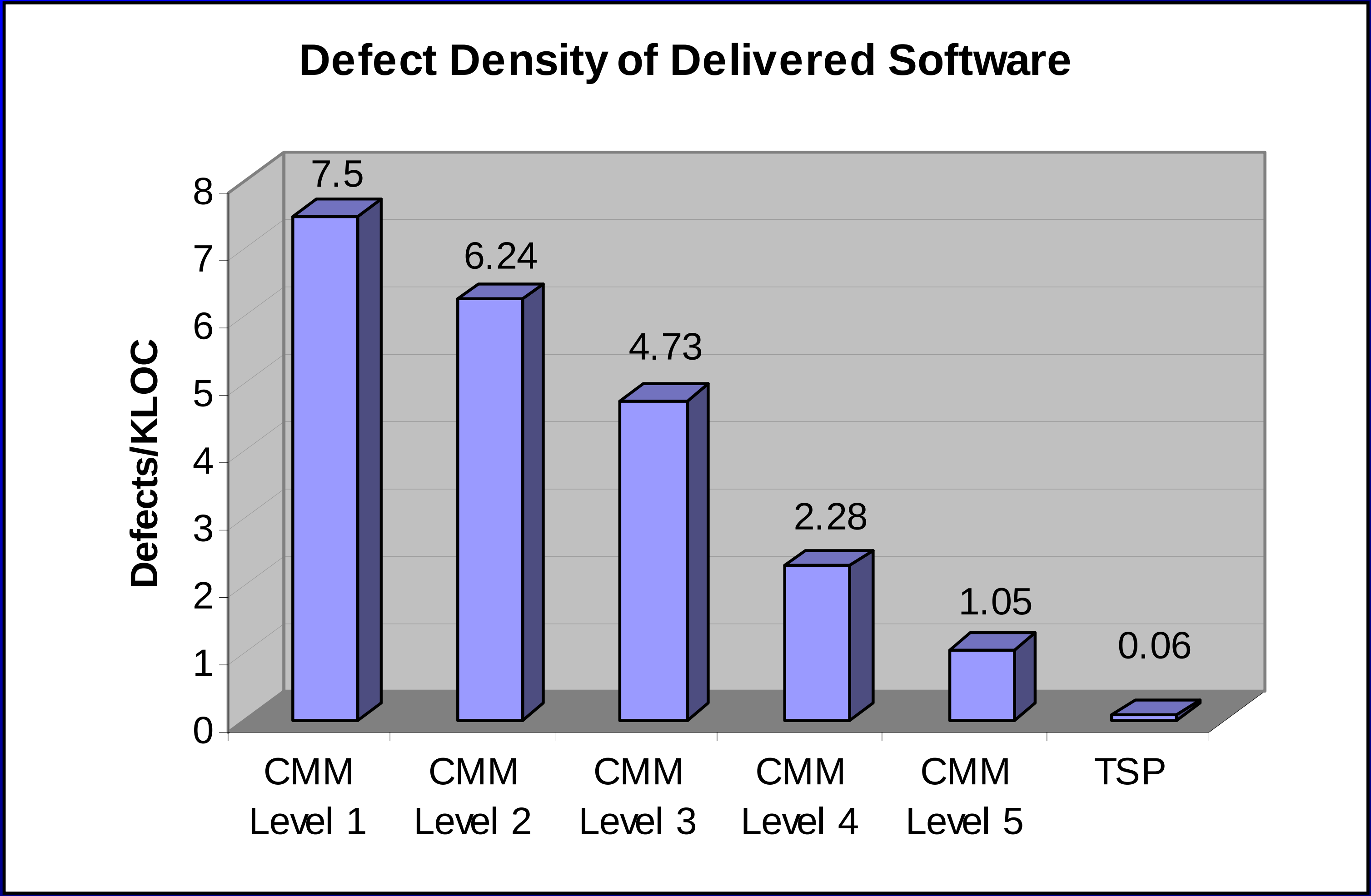
- Project schedules slip a day at a time
- If you cannot precisely measure project status, you will not know where projects stand
- Without such knowledge, you cannot address schedule problems in time to fix them
- With the TSP, you can
  - closely monitor team performance
  - address problems in time
  - consistently meet schedules

TSP Results – Task Hours

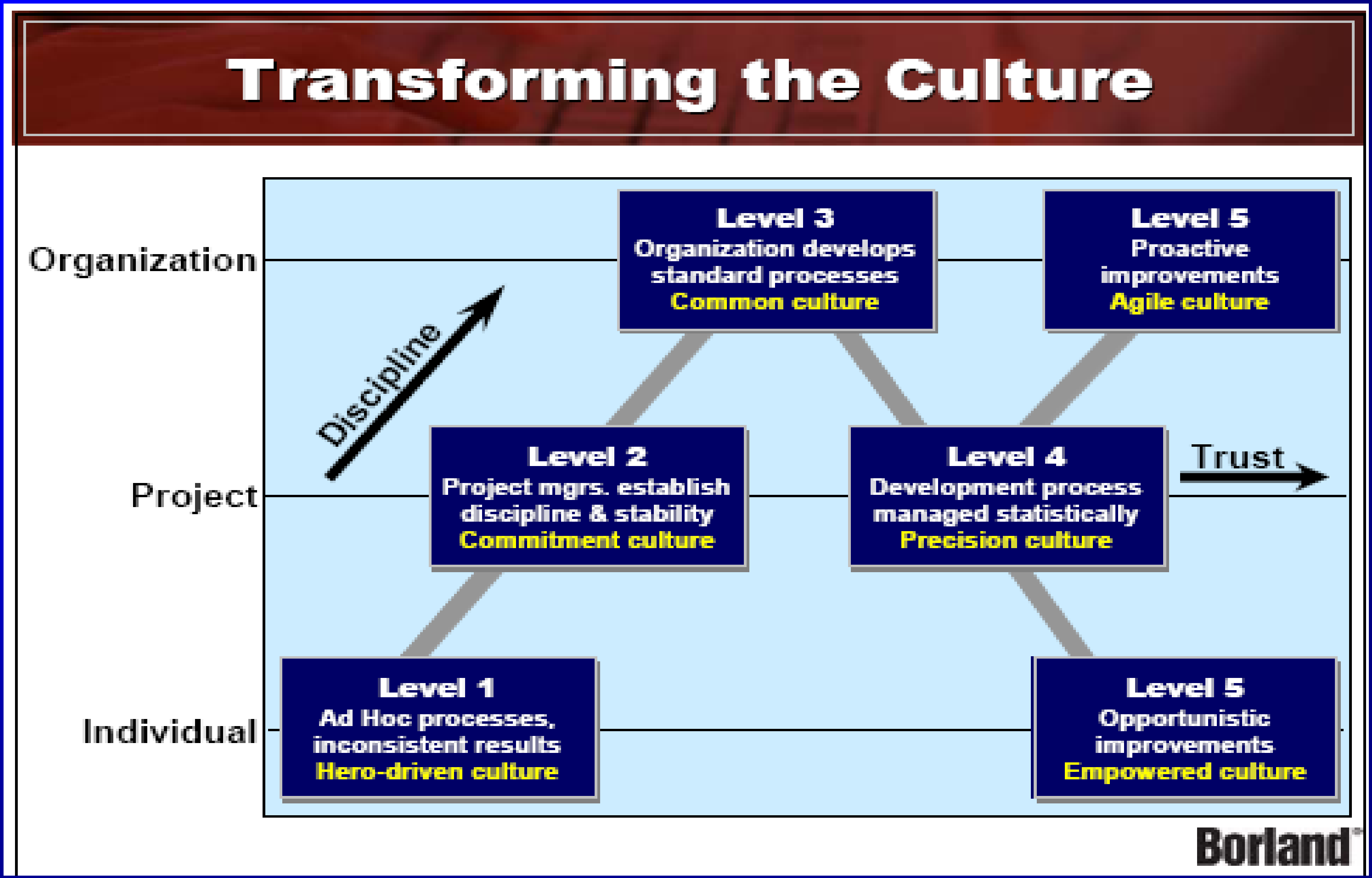


Source: Allied Signal

TSP Results - Defects



Ref: SEI Technical Report 2003-014



Source: "From MCC to CMM", Dr. Bill Curtis, DC SPIN, April 2006

Process Improvement Principles

- It takes time, skill, and money to improve the software process
- To improve the software process, someone must work on it
- Unplanned process improvement is wishful thinking
- Automation of a poorly defined process will produce poorly defined results
- **Improvements should be made in small steps**
- Train, train, train!

Source: *Managing the Software Process,* Watts Humphrey

Empowered Culture
Process Improvement Proposals (PIPS)

PROCESS IMPROVEMENT PROPOSAL (PIP)

PIP# :
Written By:
Date : **Author(s) :** **Project :**

Process Name : **Key Process Area :**

Improvement Description :

Improvement Benefits (Check One) :

- ○ Document Improvement
- ○ Reduced Cycle Time
- ○ Improved Quality
- ○ Reduced Risk

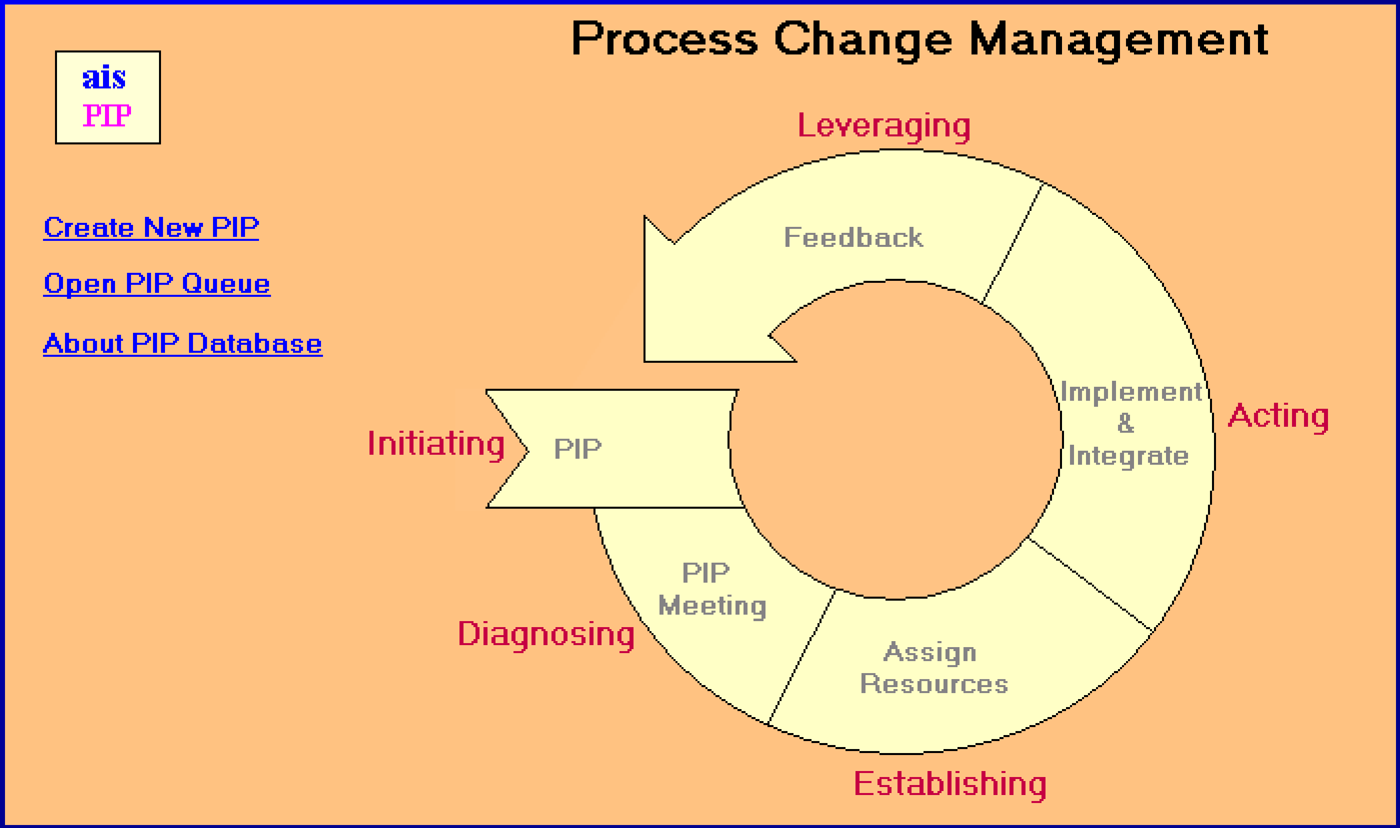
Benefits Description (Quantify Where Possible) :
(Attach files if needed)

Attach the PIP Pilot Report here (if applicable):

Submit

SEPG Evaluation

The AIS PIP Process



AIS PIPs Summary

Jan 22, 1992 – To date

No. of PIPs submitted	1502
No. of PIPs implemented:	972

No. of PIPs by improvement category:

• Improved quality	232
• Reduced cycle time	86
• Reduced risk	63
• Improved documentation	161
• Not categorized	410

Sample PIPs – Organization Process

- Incorporate the TSP into the AIS CPIW as suggested by the attached work products (ProjectCommitmentProcess.zip) which reflect the current practice
- Change Launch meeting 9A so that review is held, not only by management, but also peer Project Managers. Accordingly, these same individuals may need to be present in meeting 1B

Sample PIPs – Team Process

- For UI component enhancements, change process to do Design Inspection, Test Case Inspections and Code Inspections <u>after</u> Compile
- For components where performance requirement is critical, execute two rounds of unit test
  - Unit test of performance test cases <u>before</u> code inspection
  - Unit test of features <u>after</u> code inspection

Sample PIPs – Personal Process

- Reduce phase distribution % for Design Review for UI Components
- Update Personal Review Checklist
- Batch process E Mail three times a day
- Move end of day post mortem to start of day to process and analyze previous day's data

Lessons Learned - 1

- While models are useful to indicate where improvements are needed, only committed people can make the improvements
- A supportive management environment that rewards disciplined behavior is absolutely essential
- Timely feedback on the status and disposition of the PIPs is important to sustain the PIP mechanism and feeling of empowerment
- Do not need to wait till level 5 to start implementing process change management

Lessons Learned - 2

- While CMM is necessary as an organizational capability improvement model, it is not sufficient to change engineering behavior; the PSP provides the detailed “how to” for improvement at the individual level
- The TSP provides the management framework for continuously improving self directed teams. The PIP mechanism is key for team ownership of the project’s process and commitment to improve
- CMM, TSP, and PSP all three are needed for an integrated approach to model based improvement at the organization, team, and individual levels without the risk of sub-optimization

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Aging Aircraft Sustainment with Non-Standard Engineering

NDIA 10th Annual Systems Engineering Conference
Hyatt Regency Mission Bay, San Diego, CA
October 22-25, 2007

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Georgia Tech Research Institute

Evolution of Avionics Systems

FROM…

- Single-Function, stand-alone characterized by multiple subsystems
- Connected multiple analog signals using point-to-point wiring, to provide a single function

TO…

- Digital technology for information transfer
- Allowed network sharing of the physical interface
- Reduced number of interconnections within the airframe

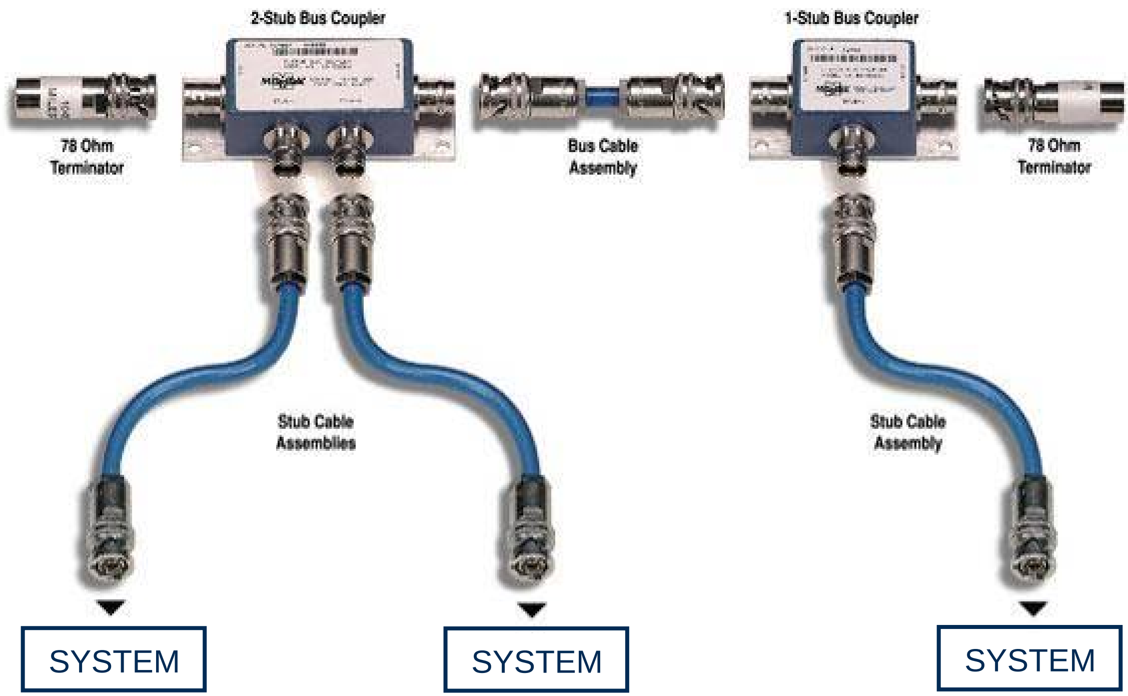
MIL-STD-1553

- Result of a cooperative effort between the military and industry
- Defines the electrical and protocol characteristics for a digital, serial communication standard among systems
- From its initial release in 1973, the standard has been revised and updated to reflect lessons learned from implementation.
- Currently standard version is revision B, Notice 6

MIL-STD-1553B Notice 6

- Defines the data bus network as a a main bus cable to which stubs are attached and terminals are connected to the stubs
- Voltage waveforms arrive at different terminals with the least amount of distortion
- Major parameters affecting waveform quality are bus length, number of stubs, and locations and lengths of stubs

A Design-to-Standard Bus



http://www.n-digital.co.jp/Milestek/diagramandtechinf/Mil1553bComp.intro.files/SVS.JPG

Non-Standard A/C 1553 Wiring Analysis

LEGACY ISSUES…

- While strides are being made to integrate avionics systems, the physical infrastructures on the target platforms may not be up to the bus standard.
- Installing wiring that conforms to the standard on any legacy system can be costly

POSSIBLE SOLUTION…

- Using non-compliant wiring installed on an aircraft, can systems reliably exchange information over the bus?
- Beneficial to derive and implement an analysis process

Non-Standard A/C 1553 Wiring Analysis

To ensure…

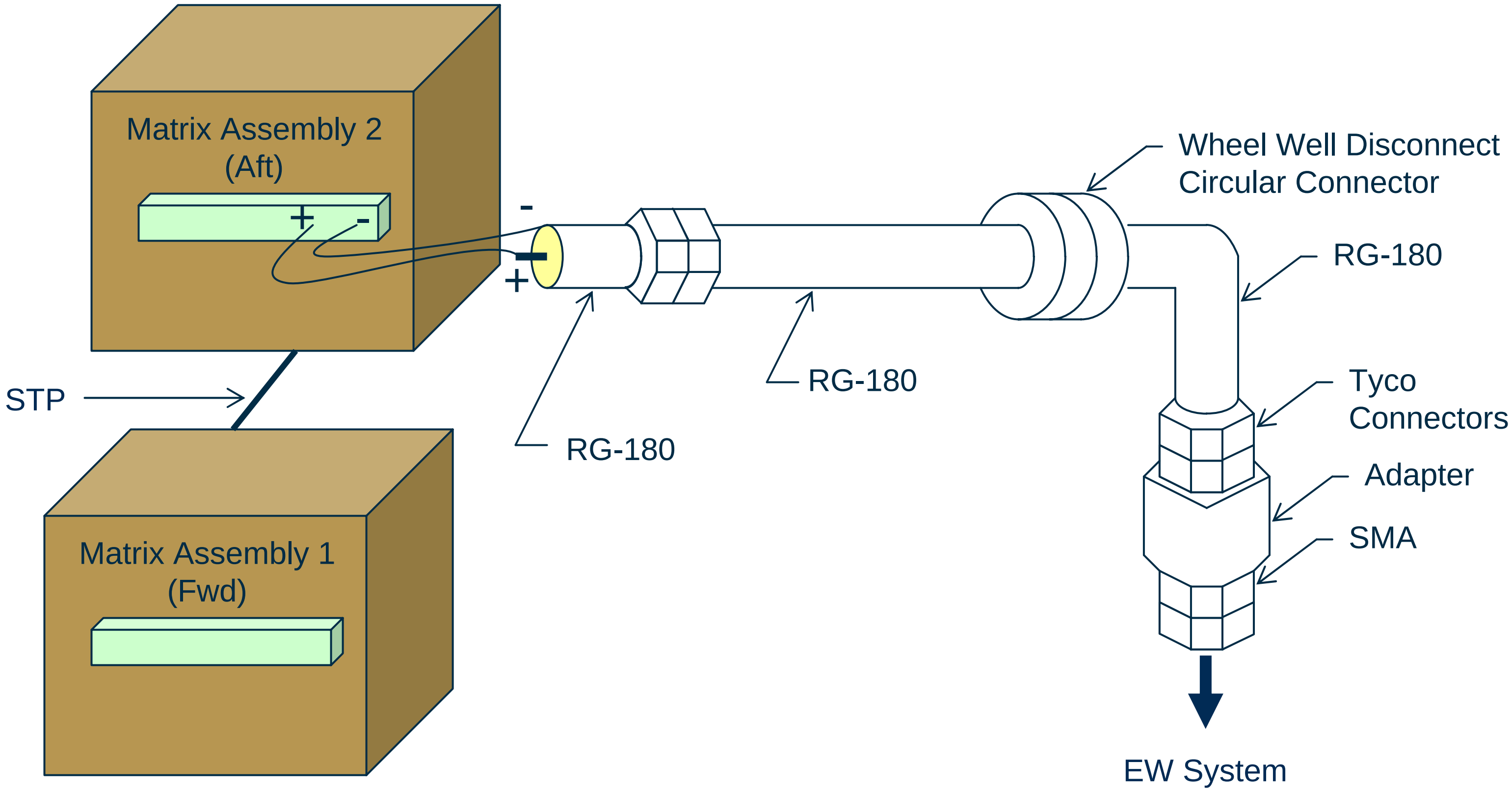
- Performance
- Maintenance
- Supportability

Plan to…

- Develop Spice Models
- Execute Lab Tests
- Perform SPICE Analysis of Actual A/C Wiring
- Perform Lab Analysis of Actual A/C Wiring

Existing A/C 1553 Wiring

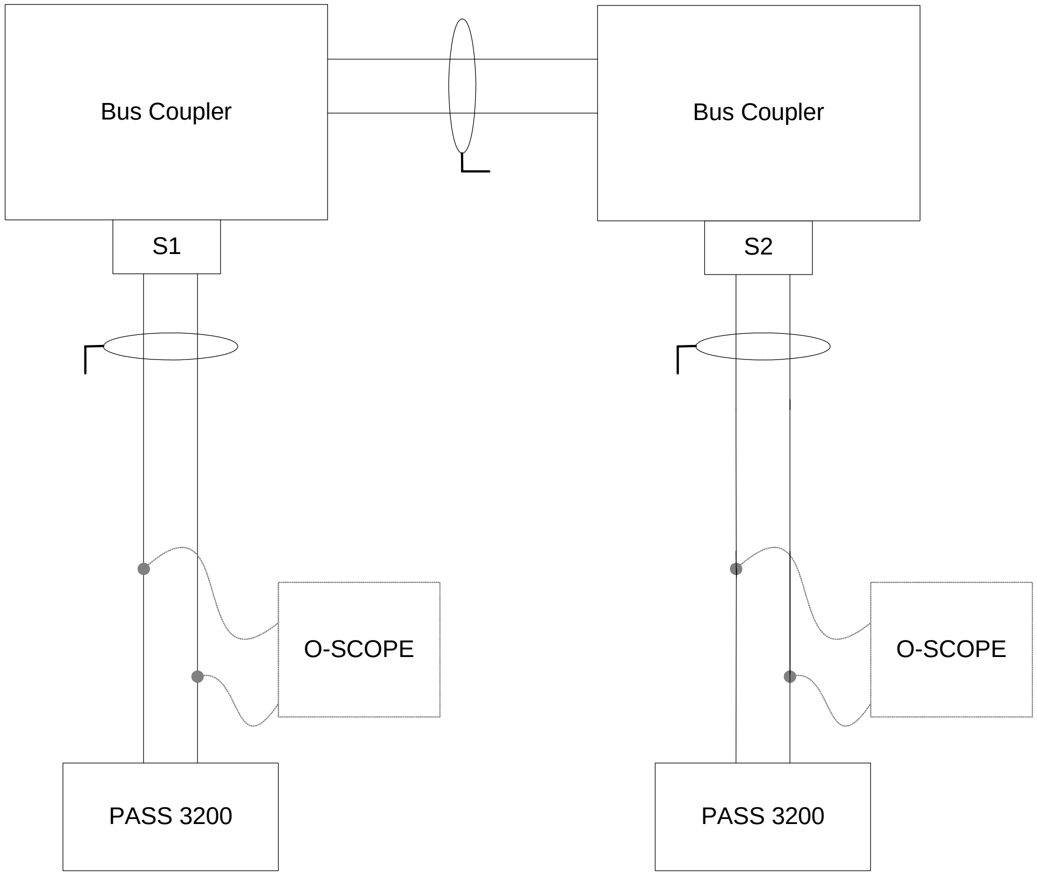
F-16C+ Block Diagram



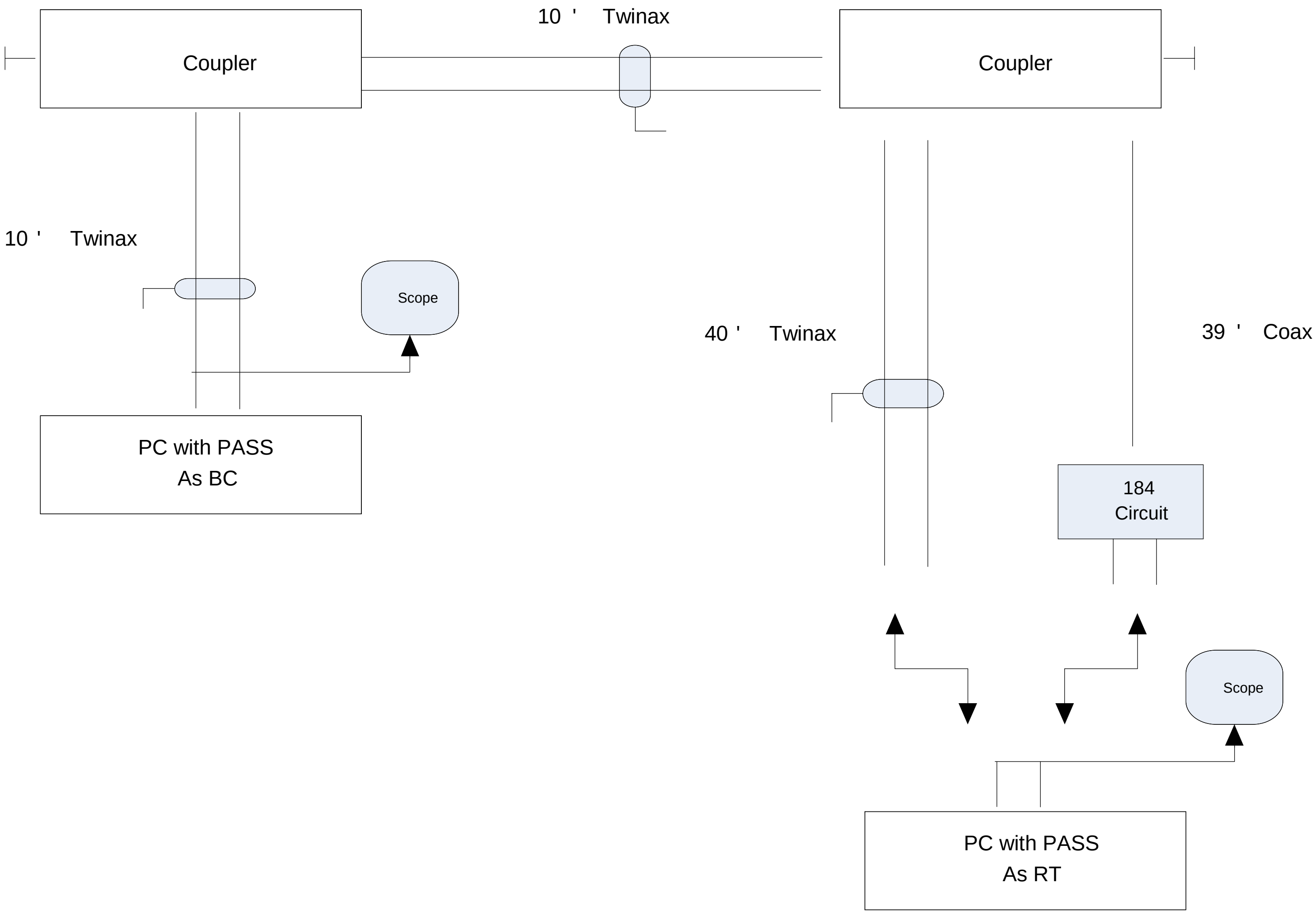
Examining Signal Quality on the Bus Network

- GOAL – To transfer voltage waveforms with minimum distortion
- To determine whether or not a network will perform reliably, its characteristics are measured and compared to the requirements of the standard.
- The quality of the waveform is determined by examining it in the following respects:
  - Amplitude
  - Zero-crossing distortion
  - Waveform tailoff

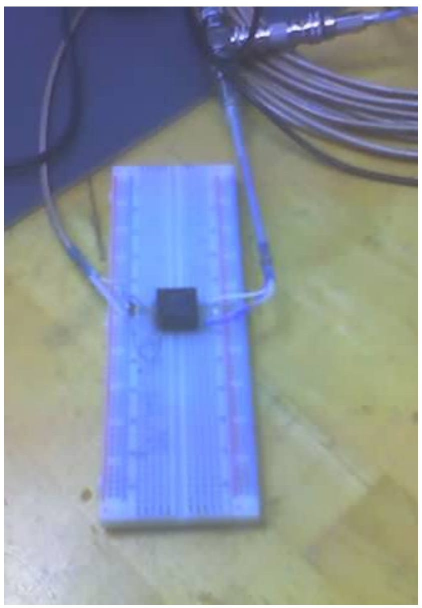
Test Waveform

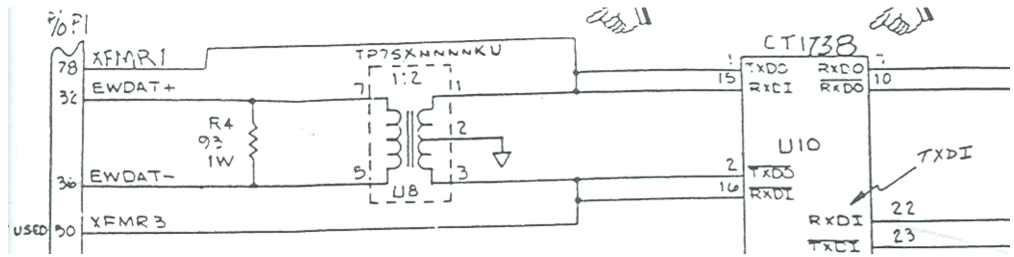


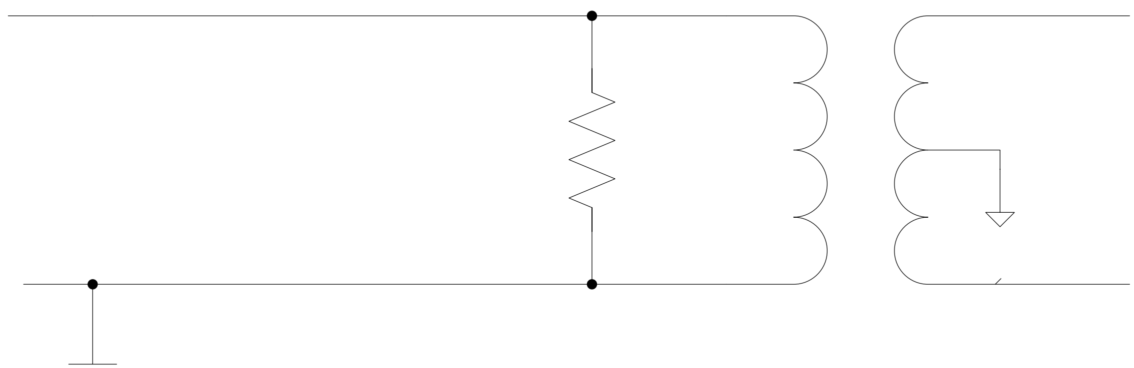
Laboratory Mockup



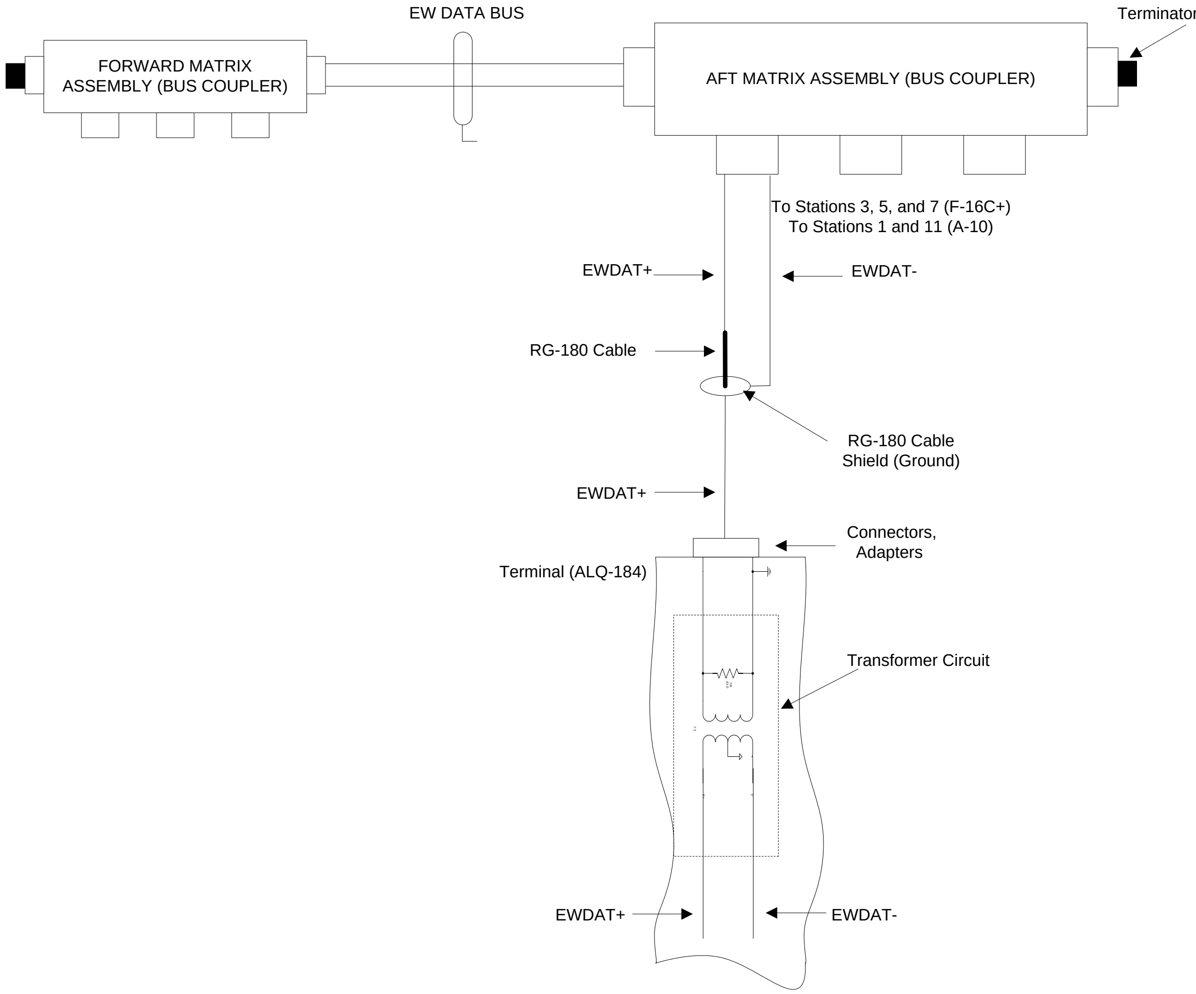
Transformer Circuit Solution







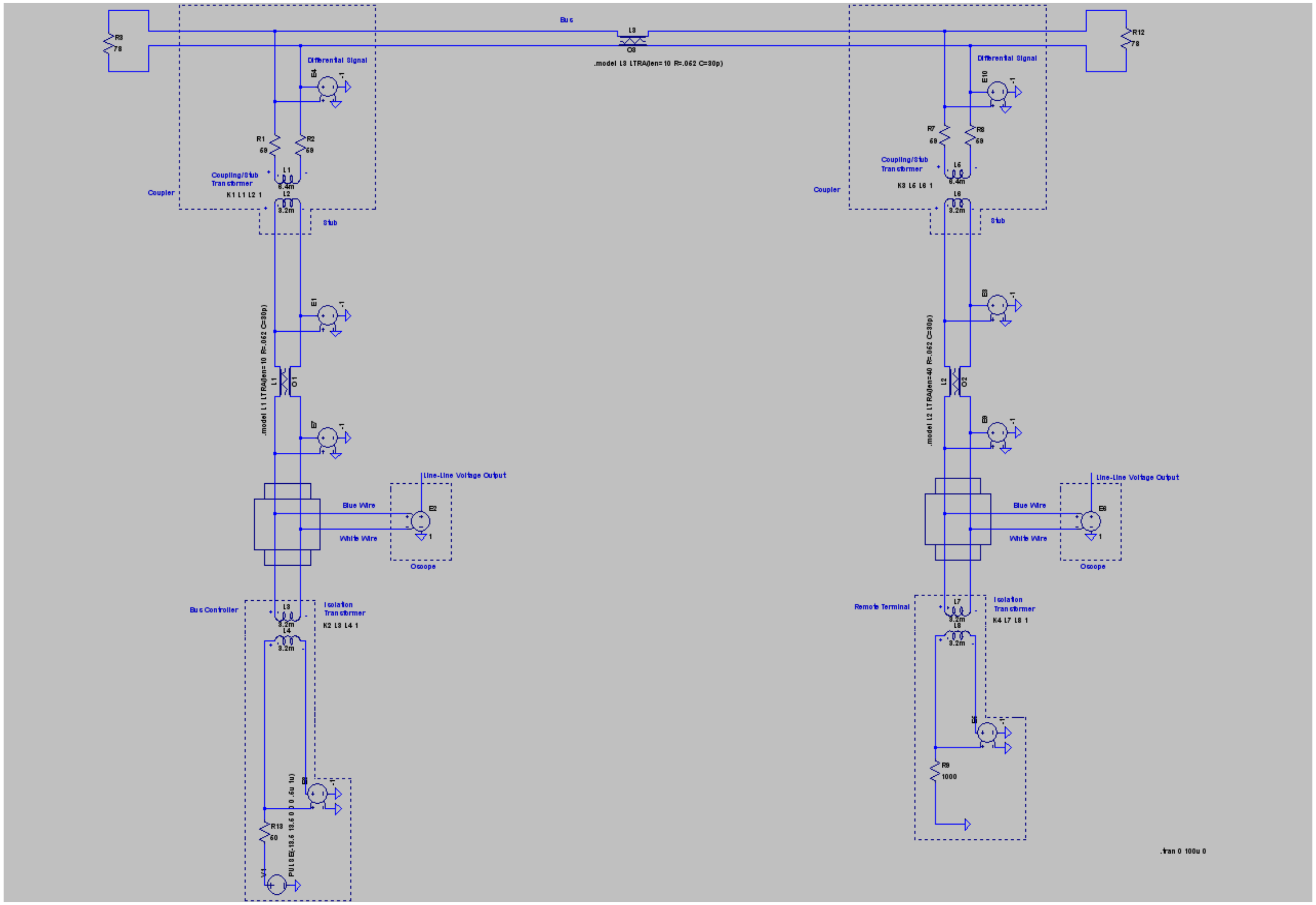
Existing A/C 1553 Wiring



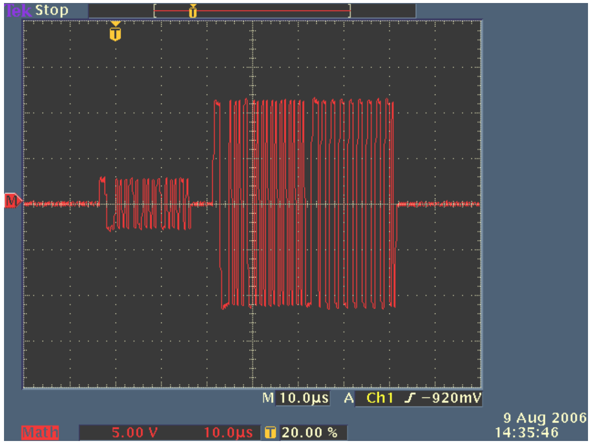
Computer Simulation

- Computer Simulation provides an approximation of the quality of the signal that can be achieved with a hardware mockup
- A SPICE program was used to model a transmission line defined by the characteristics of the standard and non-standard wiring
- The transmission line was linked to other components, i.e. resistors and transformers, to form the standard 1553 bus design

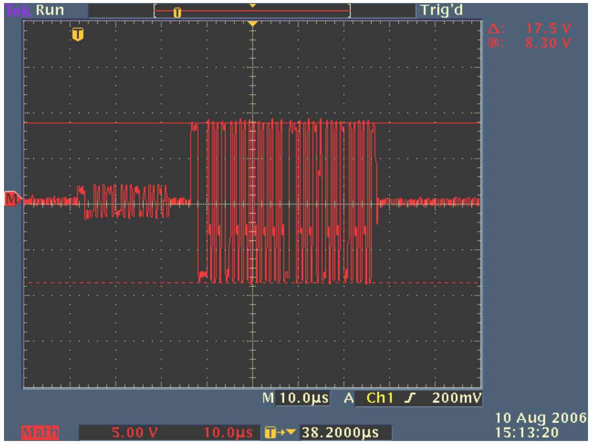
SPICE Bus Configuration



Impact of Non-Standard Wiring



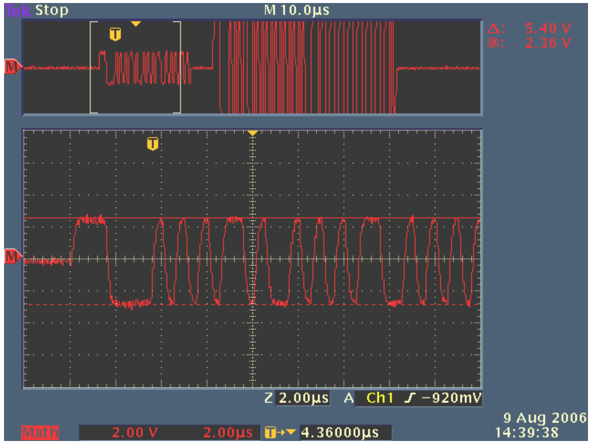
40' Twinax



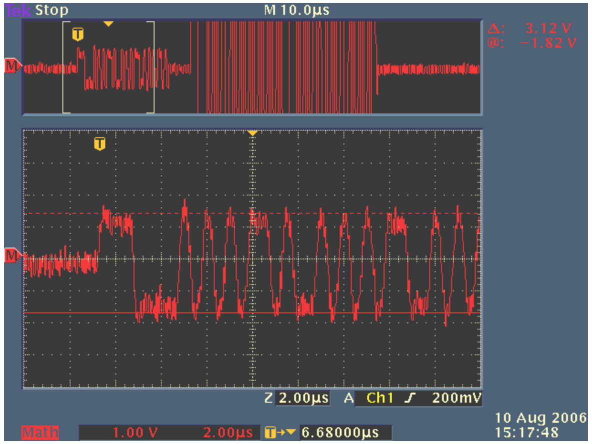
39' Coax

- BC commands one word transmit from RT (0x0C21 1-T-1-1)
- RT answers with status word followed by 1 data word
- Examine waveform quality (MIL-HDBK-1553, § 40.9)
  - Amplitude
  - Zero-crossing distortion
  - Tailoff

Input Waveform Amplitude at RT



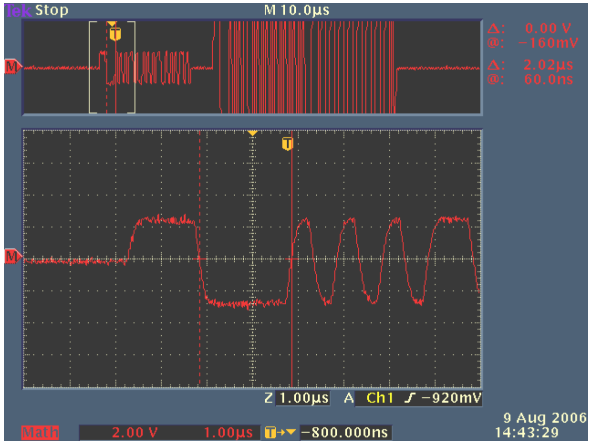
40’ Twinax



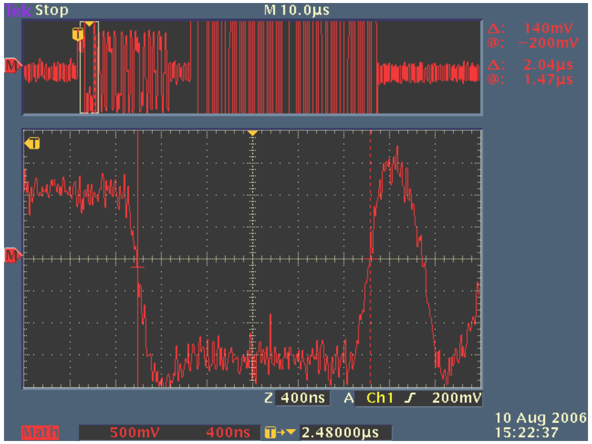
39’ Coax

- **Measured Voltage**
  - **Twinax: 5.4 v**
  - **Coax: 3.12 v**
- **Requirement: 0.86 – 14.0 v**

Input Waveform Zero-Crossing at RT



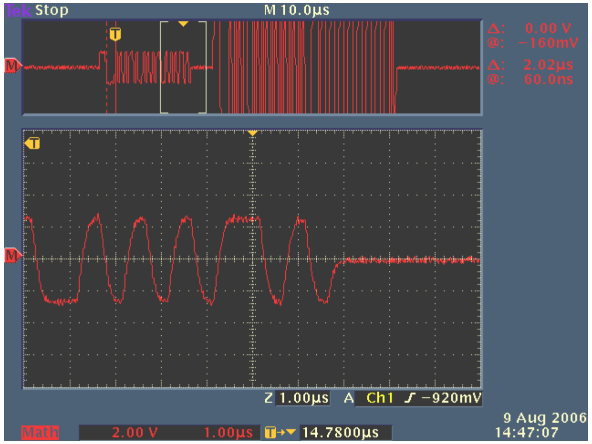
40’ Twinax

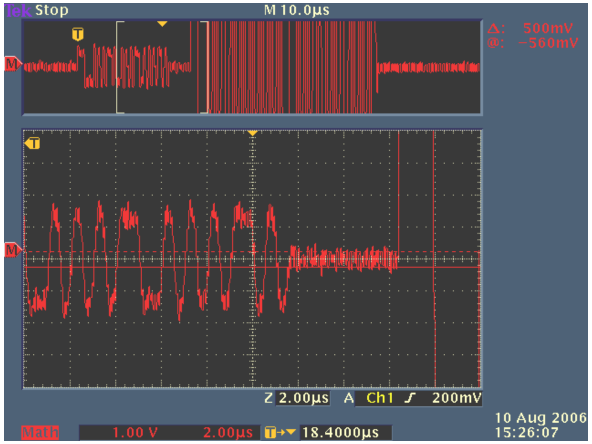


39’ Coax

- Measurement shown is zero-crossing for first bit of command word to the first bit of the data word
- Measured Time
  - Twinax: 2.02 µs
  - Coax: 2.04 µs
- Requirement: 2 µs ±150 ns

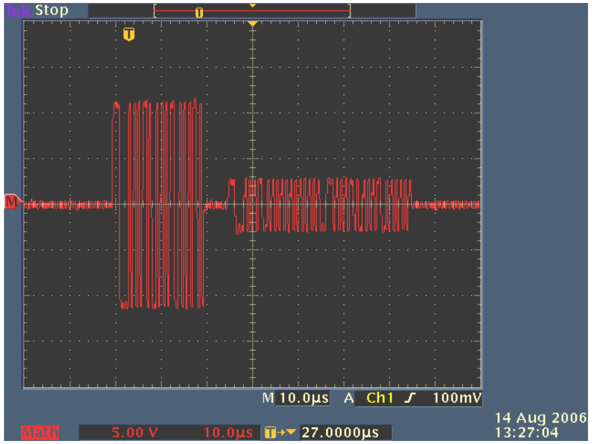
Input Waveform Tailoff at RT

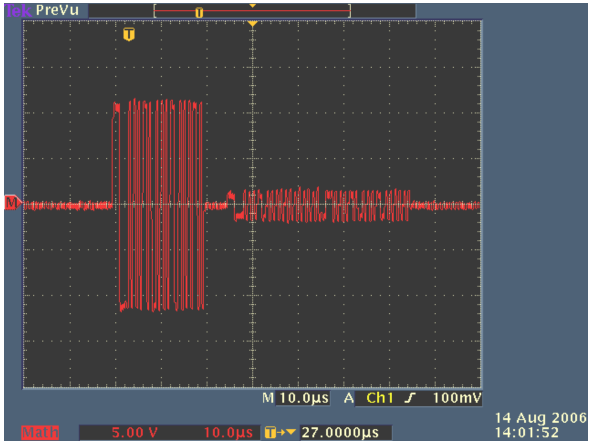




- Voltage must be less than ±250 mV for the period beginning 2.5 µs following the last mid-bit zero-crossing.
- Both waveforms exhibit clear end to data waveform.

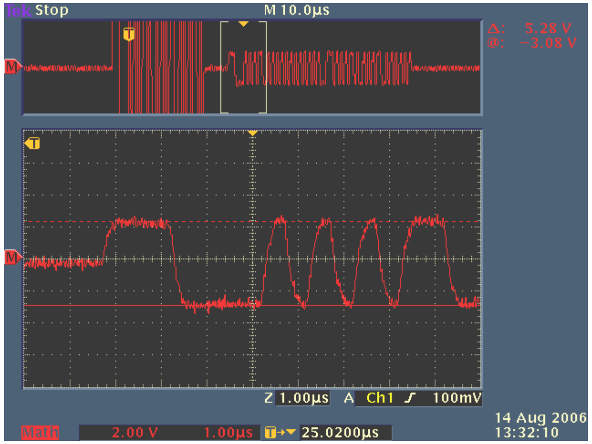
Impact of Non-Standard Wiring – BC



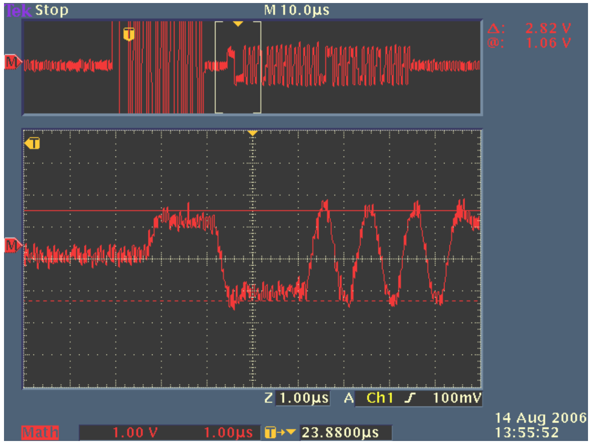


- BC commands 1-word transmit from RT 1 (0x0C21 1-T-1-1)
- RT 1 answers with status word followed by 1 data word
- Examine waveform quality (MIL-HDBK-1553, § 40.9)
  - Amplitude
  - Zero-crossing distortion
  - Tailoff

Input Waveform Amplitude at BC



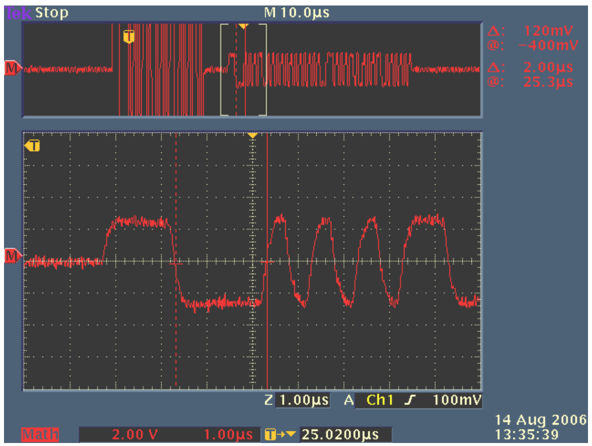
40’ Twinax



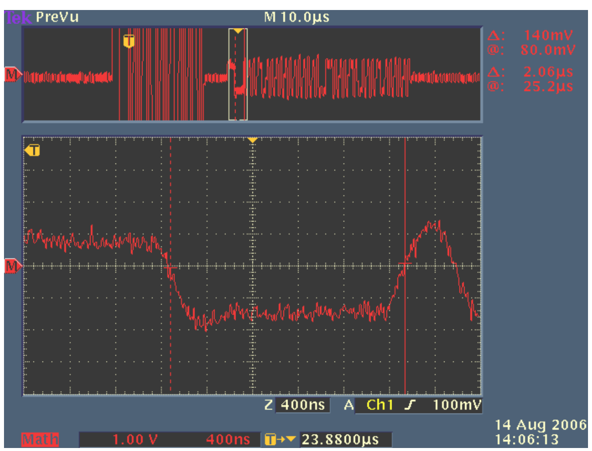
39’ Coax

- **Measured Voltage**
  - **Twinax: 5.28 v**
  - **Coax: 2.82 v**
- **Requirement: 0.86 – 14.0 v**

Input Waveform Zero-Crossing at BC



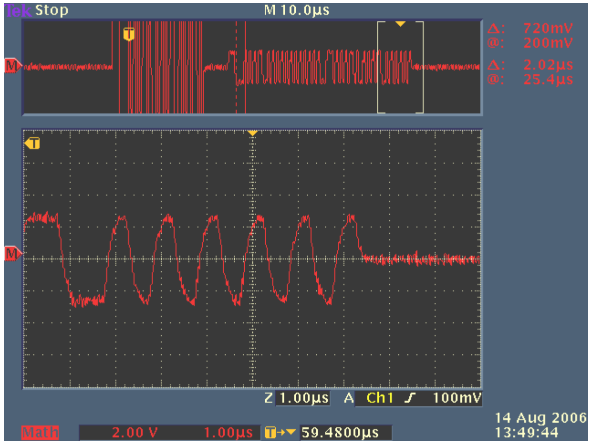
40' Twinax

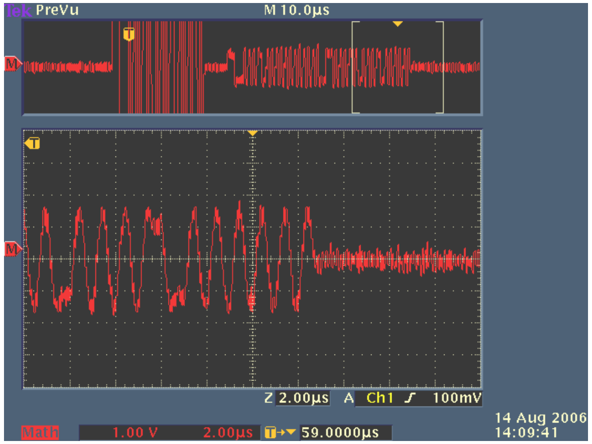


39' Coax

- **Measurement shown is zero-crossing for first bit of command word to the first bit of the data word**
- **Measured Time**
  - **Twinax: 2.0 µs**
  - **Coax: 2.06 µs**
- **Requirement: 2 µs ±150 ns**

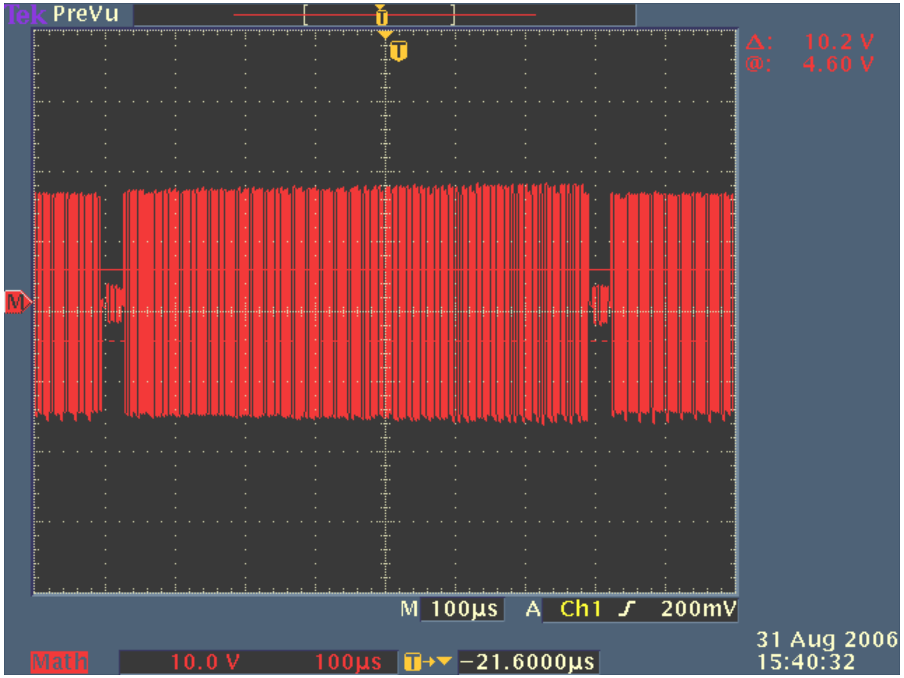
Input Waveform Tailoff at BC





- Voltage must be less than ±250 mV for the period beginning 2.5 µs following the last mid-bit zero-crossing.
- Both waveforms exhibit clear end to data waveform.

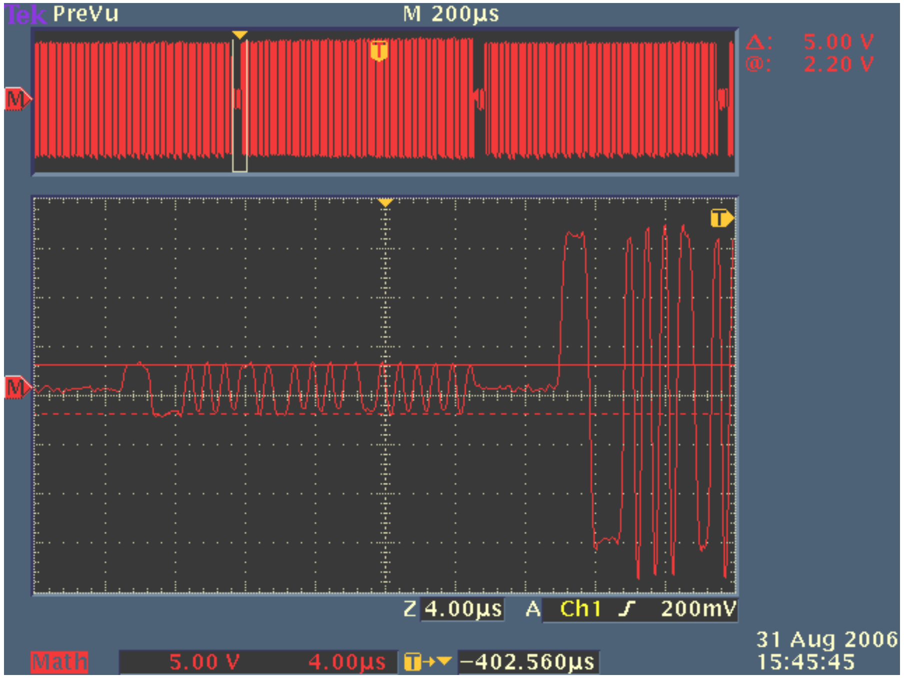
Impact of High Traffic Level



- Maximum bus loading was added to the analysis
- Message changed to a 32-word transfer at the minimum inter-message gap, resulting in a bus loading at just over 99%

Impact of High Traffic Level

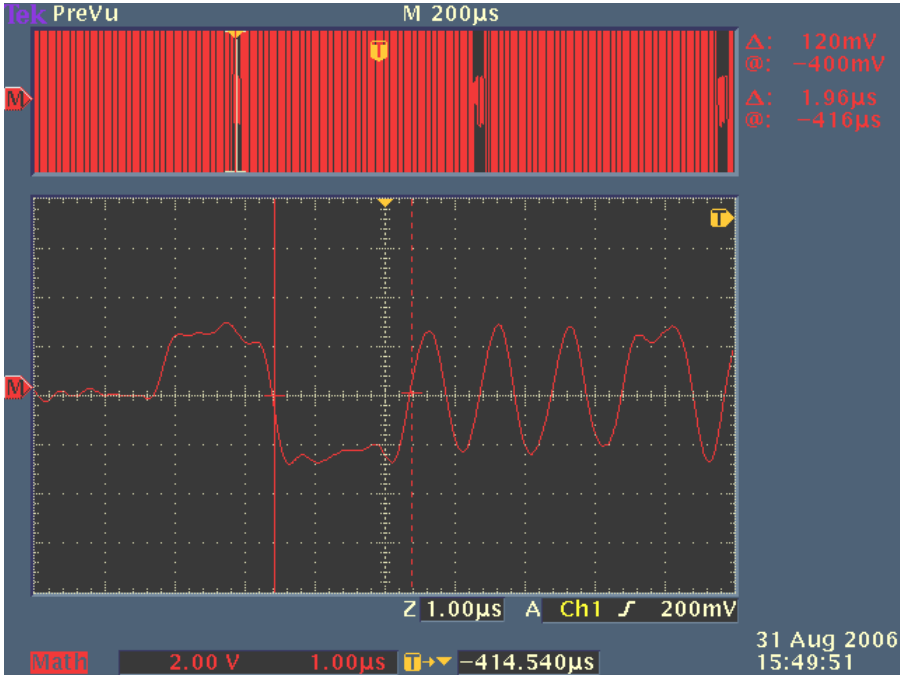
Input Waveform Amplitude



- **Measured Voltage**
  - **5.0 v**

Impact of High Traffic Level

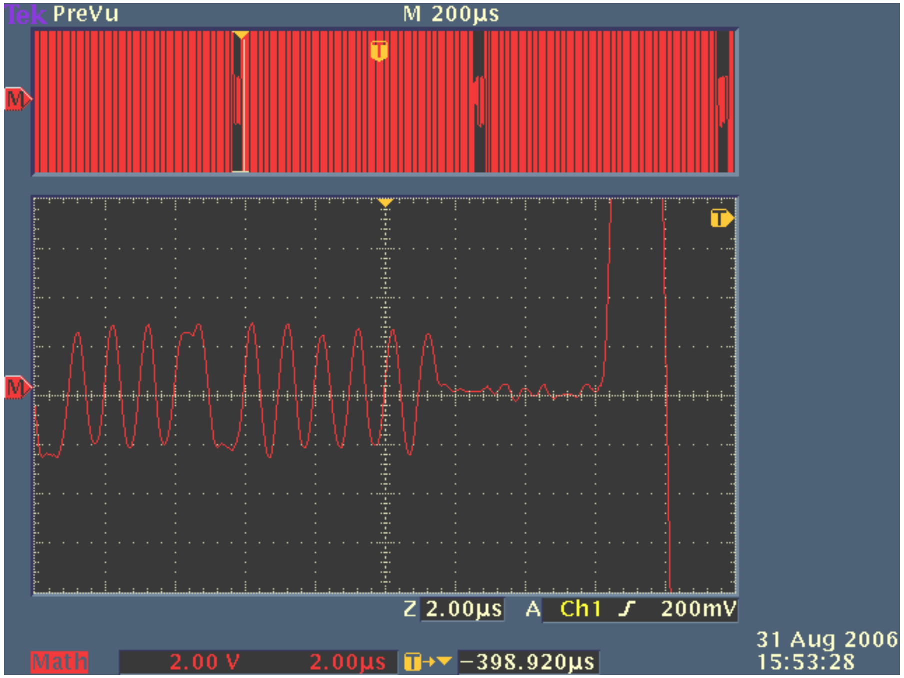
Zero-crossing Deviation



- **Measured Time**
  - **1.96 µs**

Impact of High Traffic Level

Input Waveform Tailoff



- The waveform exhibits a clear end to data waveform

Use of non-standard wiring OK?

- Short answer: Yes.
- What gets “done-to” should be “un-done” at the terminal end.

Non-Standard A/C 1553 Wiring Analysis

- Sufficient Performance
- Low Maintenance
- Easy Supportability
- Minimal Cost

Architecture-Based Concept Evaluation in Support of JCIDS

Dave Jacques, Ph.D.
John Colombi, Ph.D.

NDIA 10th Annual Systems Engineering Conference
22-25 Oct 07

Architecture Based Concept Evaluation

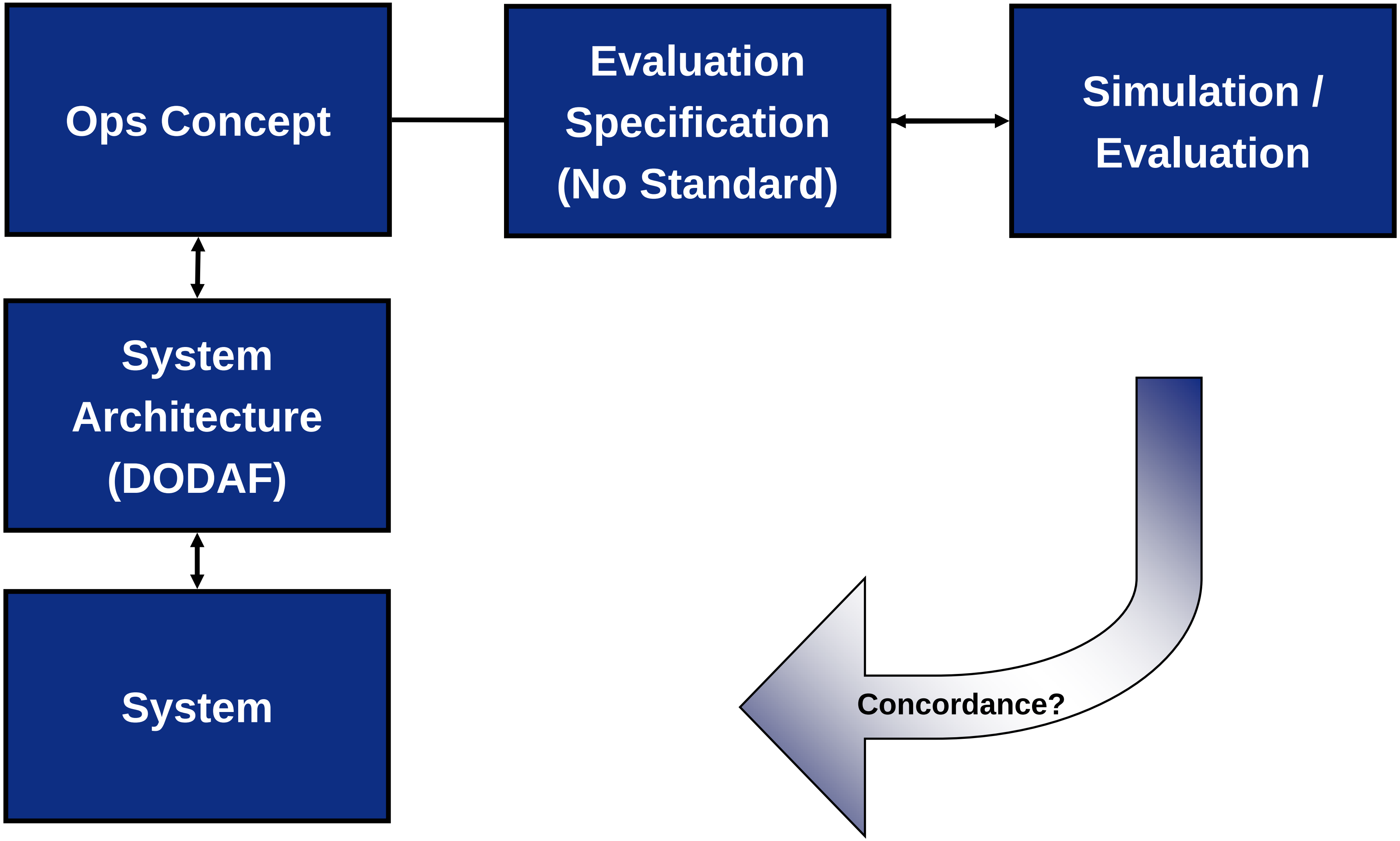
Based on research sponsored by:

AFRL/MN Eglin AFB

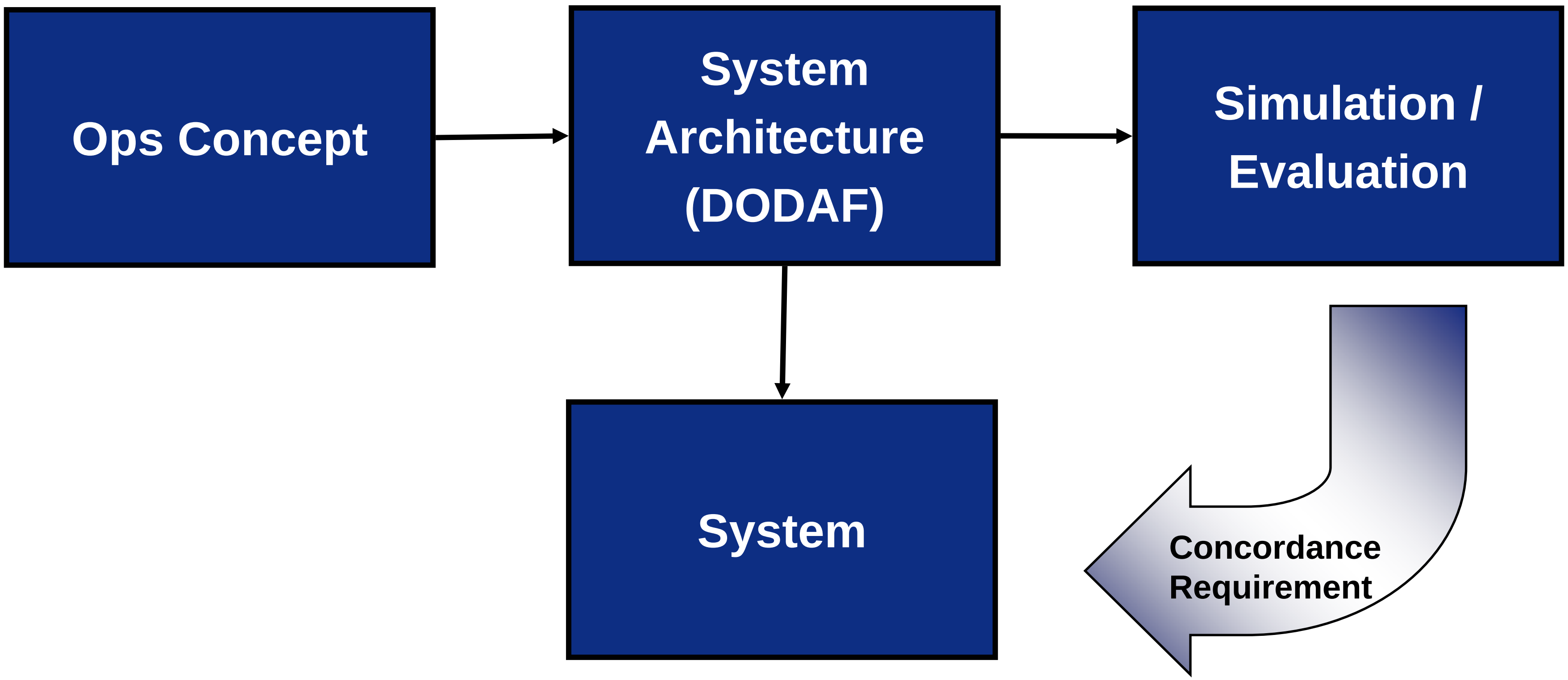
Thanks to Systems Engineering Graduate Students:

Major Tor Dietrichs, Major Richard Griffin
Major Adrian Schuettke, Major Mark Slocum

Architecture versus M&S?



Bridge the Gap
Architecture and M&S



U.S. AIR FORCE

Introduction

Research Objectives / Implications

Demonstrate an improved <u>process</u> of using <u>architectures</u> to <u>evaluate/refine</u> a proposed system <u>concept</u>

Application:

<u>Weapon Borne Battle Damage Assessment (WBBDA)</u>

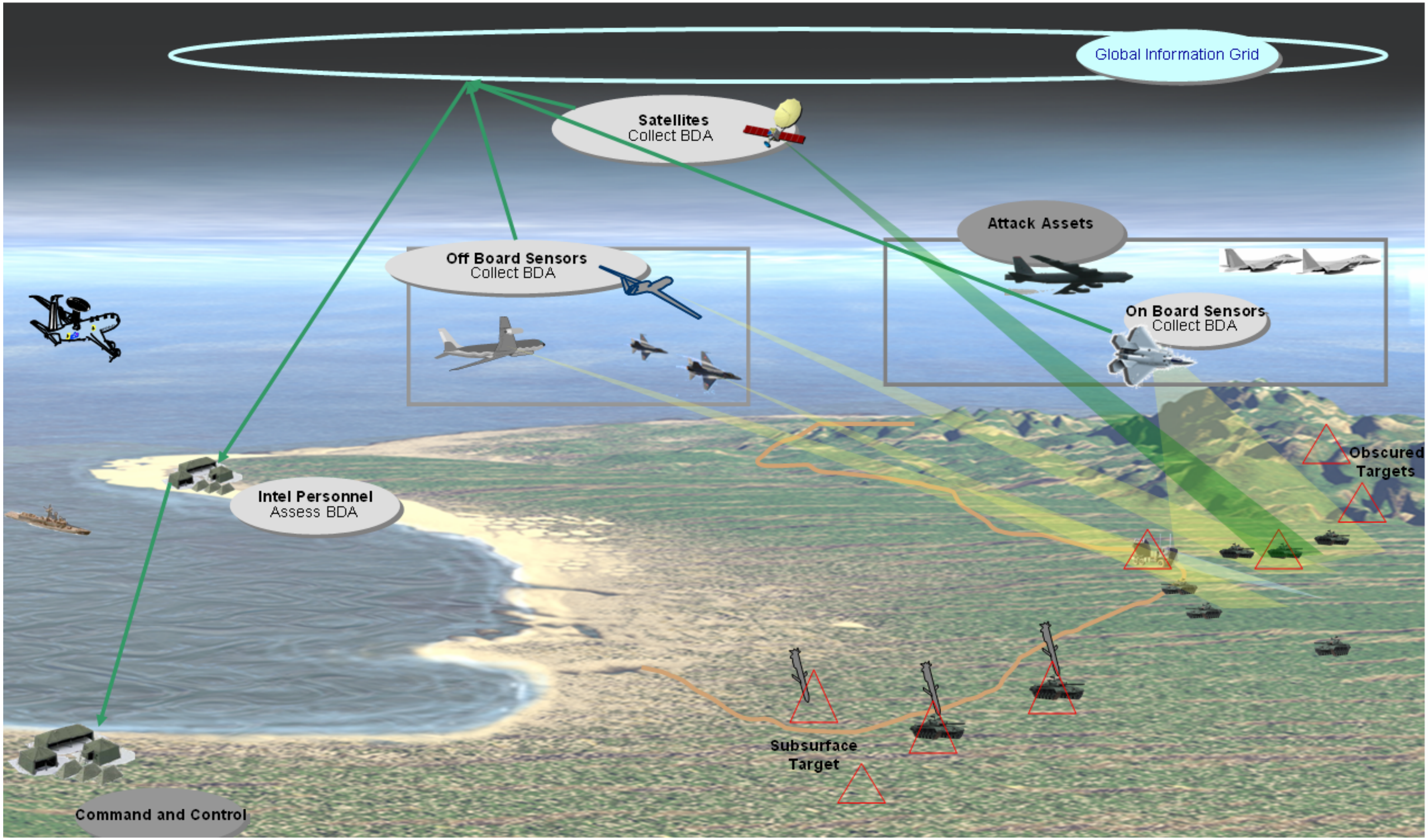
System Concept (2015-2025 time frame)

- **Develop DODAF system architectures (both “as-is” and “to-be”)**
  - **Key Products: OV-1, OV-2 (nodes), OV-5 (activities), OV-6a (rules), OV-6b (state transition diagram, or discrete event sim), OV-7 (data)**
- **Develop evaluation models directly from the system architectures**
- **Analyze results to identify key design parameters that can translate to system requirements and Key Performance Parameters in the JCIDS**

Methodology

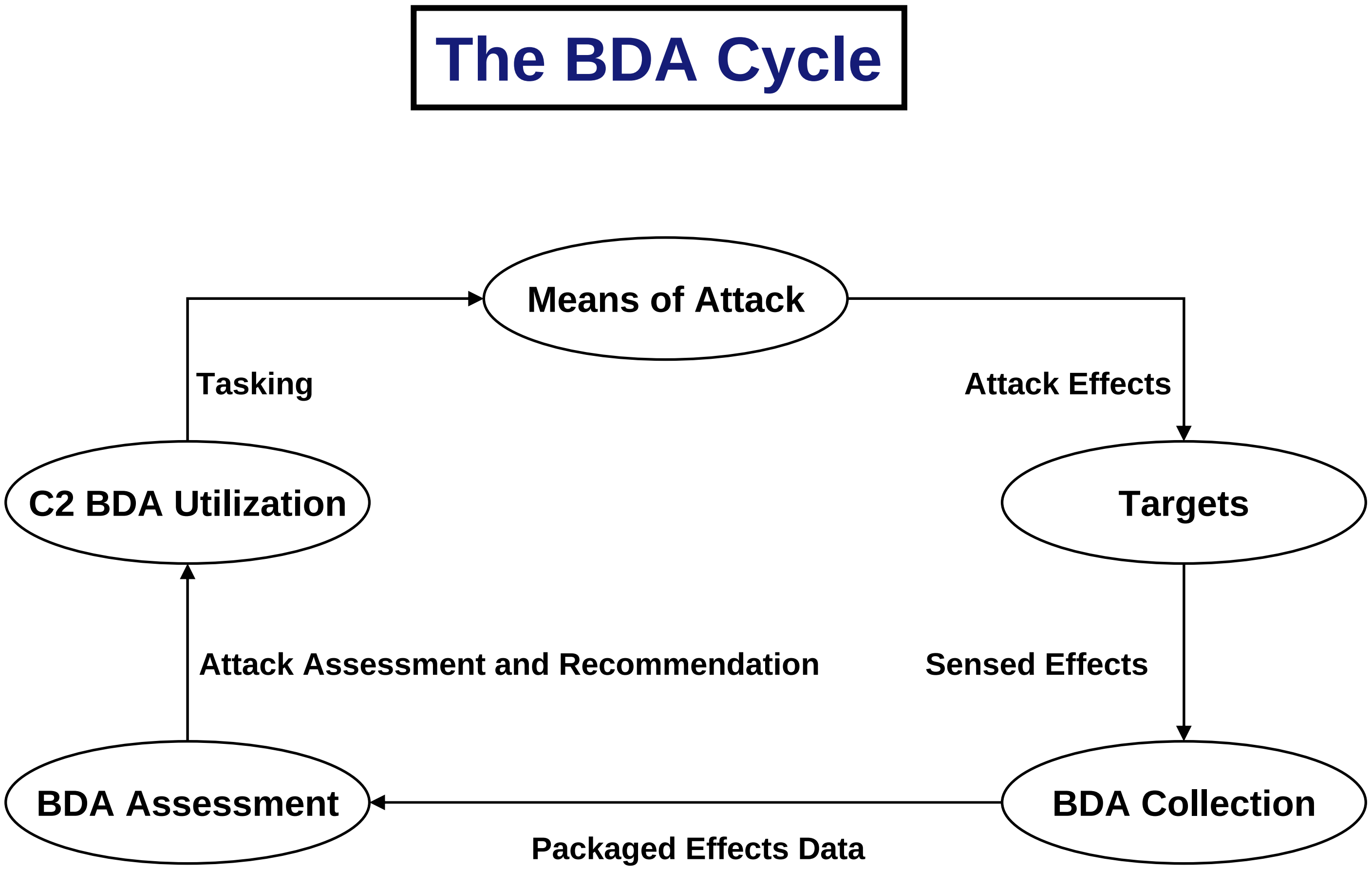
- Develop Architecture <u>based on joint ops concept</u>
  - DoDAF architecture views
  - Compare AS-IS and TO-BE architectures
- Develop and use simulations <u>based on architecture</u>
  - Analytical Model – Excel, with Decision Analysis add-in
  - Discrete Event Simulation– Rockwell Arena
- Evaluate the system concept based on the results

Current BDA Ops Concept
OV-1

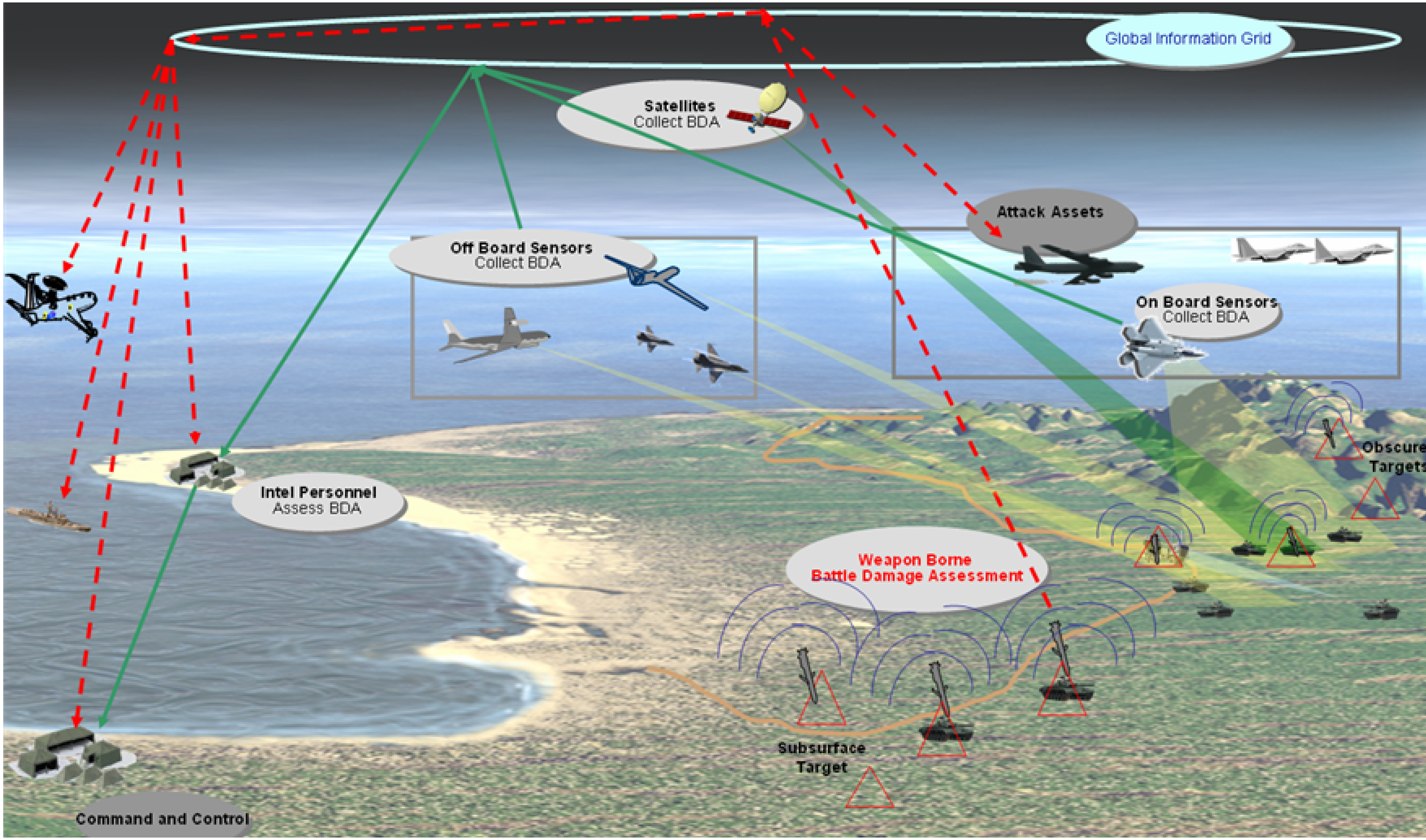


Architecture

AS-IS OV-2 Operational Node Connectivity

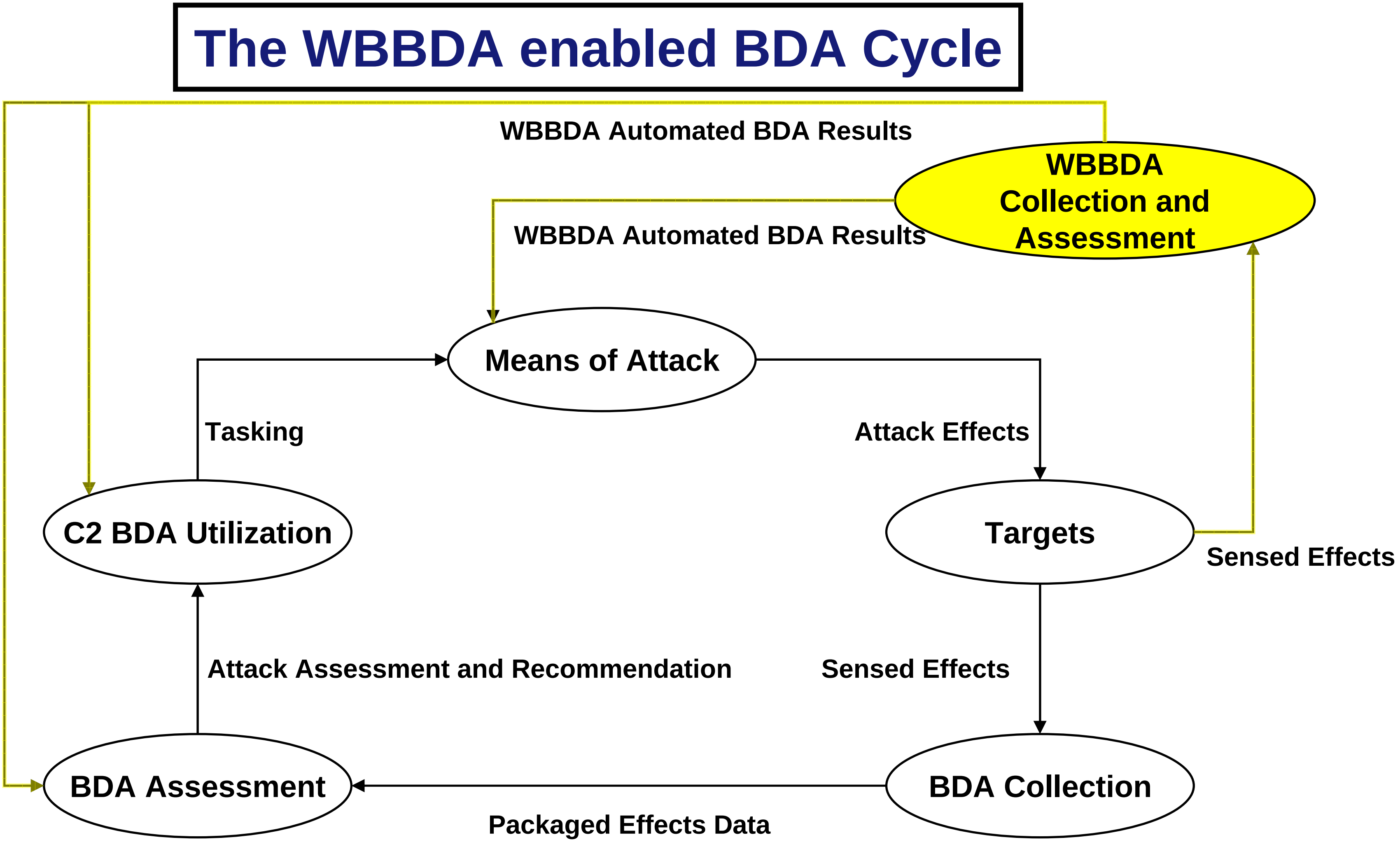


So what is WBBDA?
“To-Be” OV-1

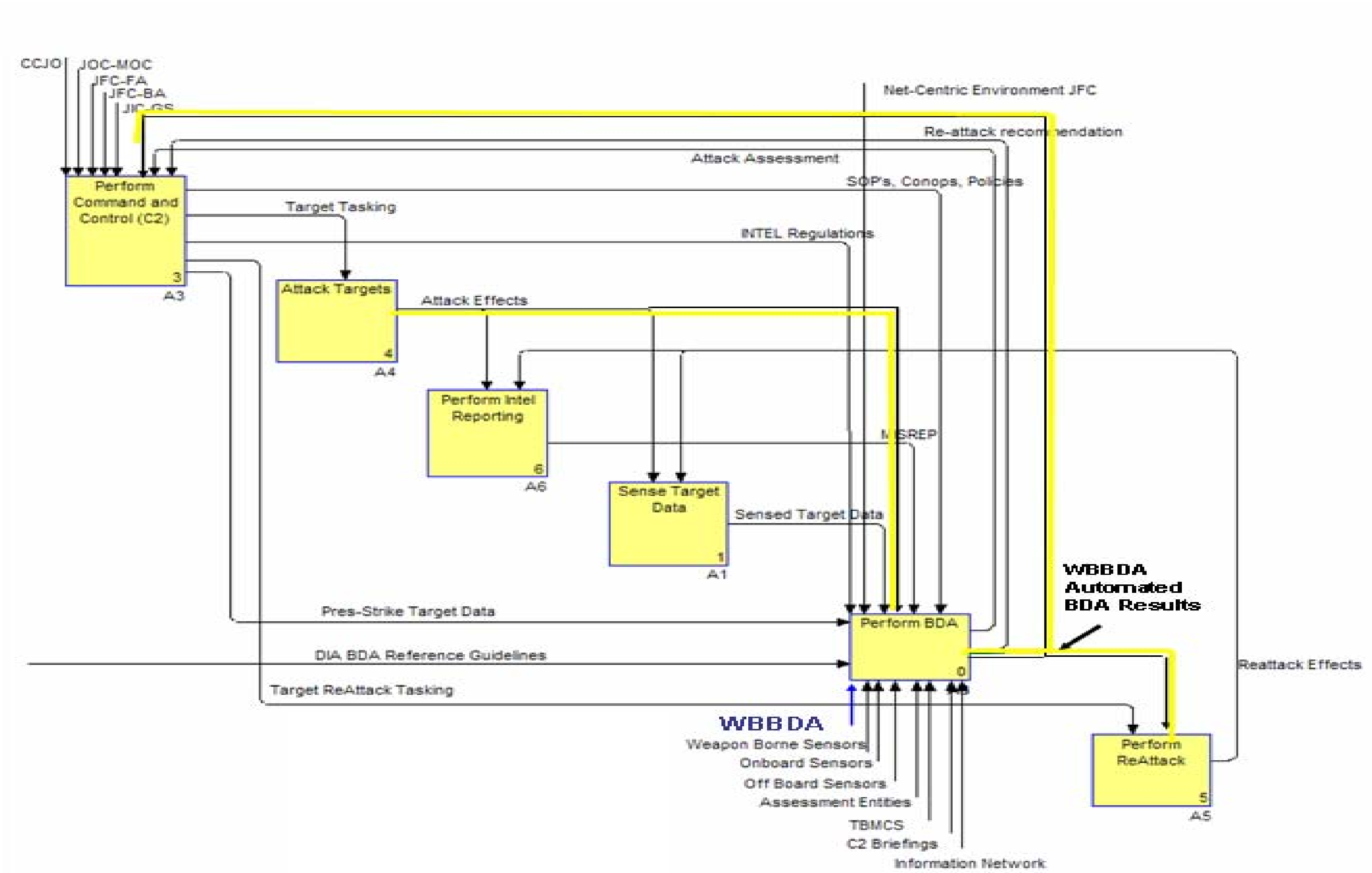


Architecture

TO-BE OV-2 Operational Nodes Diagram



OV-5 Activity Diagram



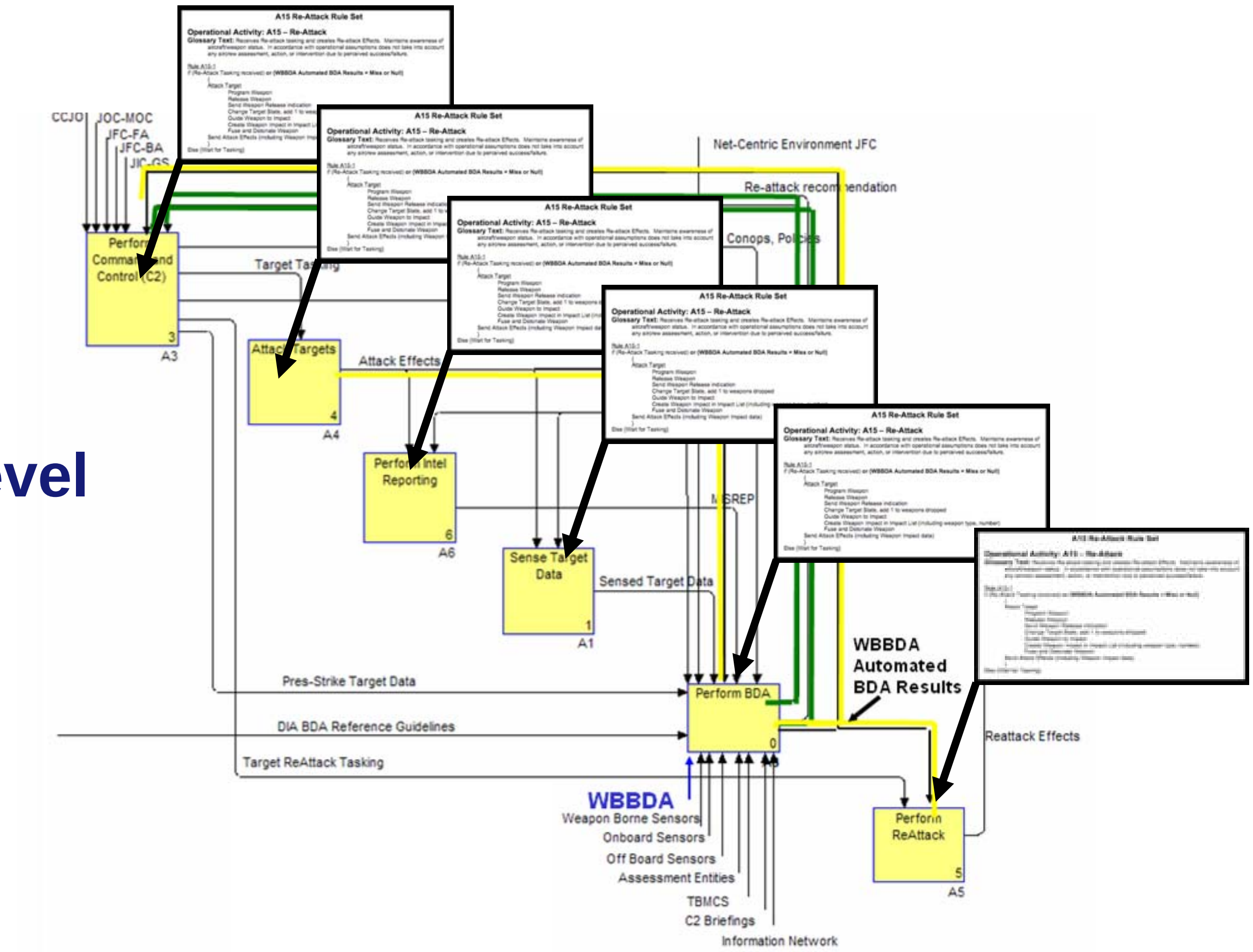
Architecture
OV-6a Rules Model

At ESD Level…

Major Combat Operations

…and System Level

Perform BDA



Architecture
Method for Metrics

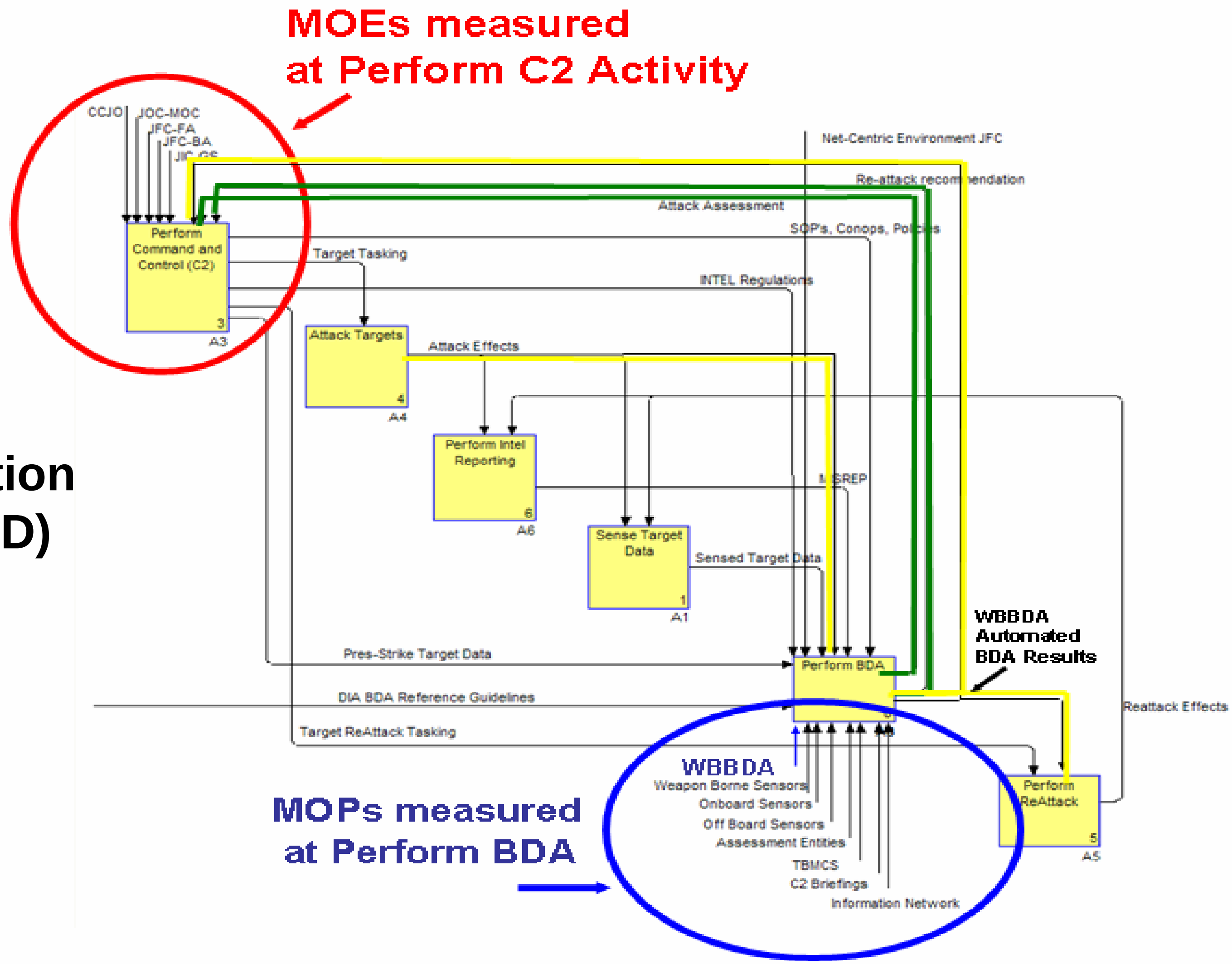
- **MOEs Established in ICD**

Measure of Effectiveness	Numerator	Denominator
1. AOR Coverage (AORC) – % of targets that receive BDA results	# targets BDA is collected on	# of targets attacked per package
2. Total Time-Obscured Target (TT-OT)–Looks at total time from the completion of the attack strike (on obscured targets) to the point when all BDA assessment and dissemination is complete.	time	n/a
3. Total Time– Subsurface Targets (TT-ST) Looks at total time from the completion of the attack strike (on subsurface targets) to the point when all BDA assessment and dissemination is complete.	time	n/a
4. Package Effectiveness (PE)	# targets killed	# of packages
5. Package Planning Effectiveness (PPE)	# targets attacked	# of packages
6. Attack Effectiveness (AE)	# targets killed	# targets attacked
7. Weapons per Target Kill (WPTK)	total # of weapons dropped	# targets killed

Architecture

Method for Metrics

- Initial system views did not capture MOE's
- Built additional views at higher level of abstraction for visibility (ESD)
- Established Traceability



Single Package Model
Traceability to MOEs

- Purpose: Construct analytical model based on architecture to evaluate the WBBDA system concept

- Model outputs values for the following MOEs:
  - Package Planning Effectiveness (PPE)
    = # of targets attacked
  - Package Effectiveness PE
    = # of targets destroyed
  - Attack Effectiveness AE
    = # targets destroyed / # targets attacked
  - WPTK = # weapons used per target destroyed

Single Package Model
Key Terms

- $\underline{P_k}$ – probability of kill (hit) based on all non-WBBDA factors (weapon performance, delivery system performance, etc.)

- <u>Accuracy</u> – probability WBBDA correctly determines a hit / miss

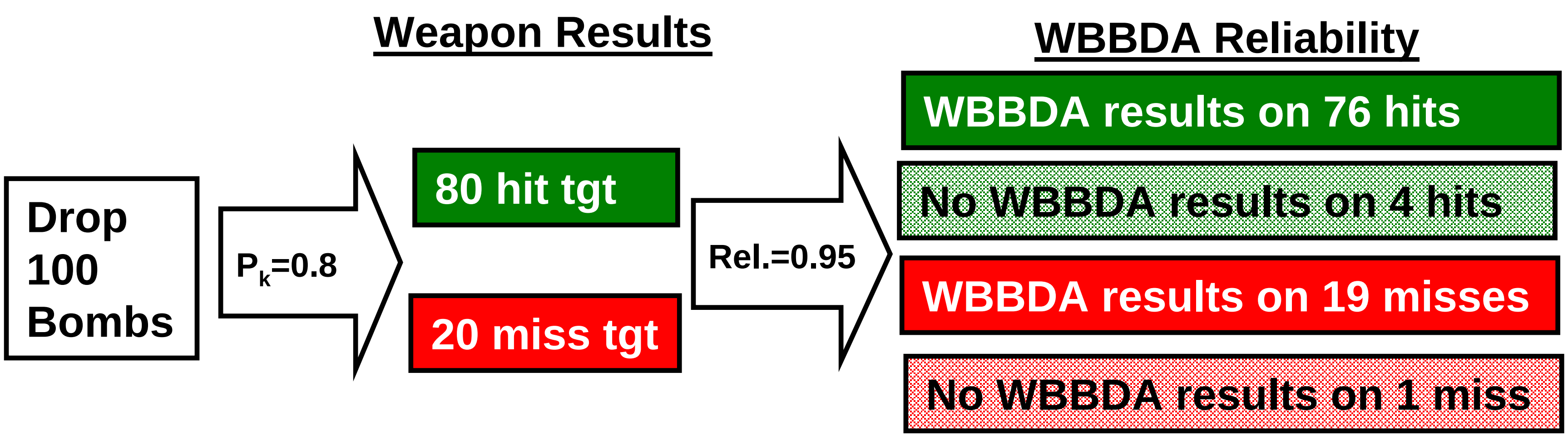
- <u>Reliability</u> – probability WBBDA correctly transmits and displays a hit / miss

Single Package Model
Scenarios

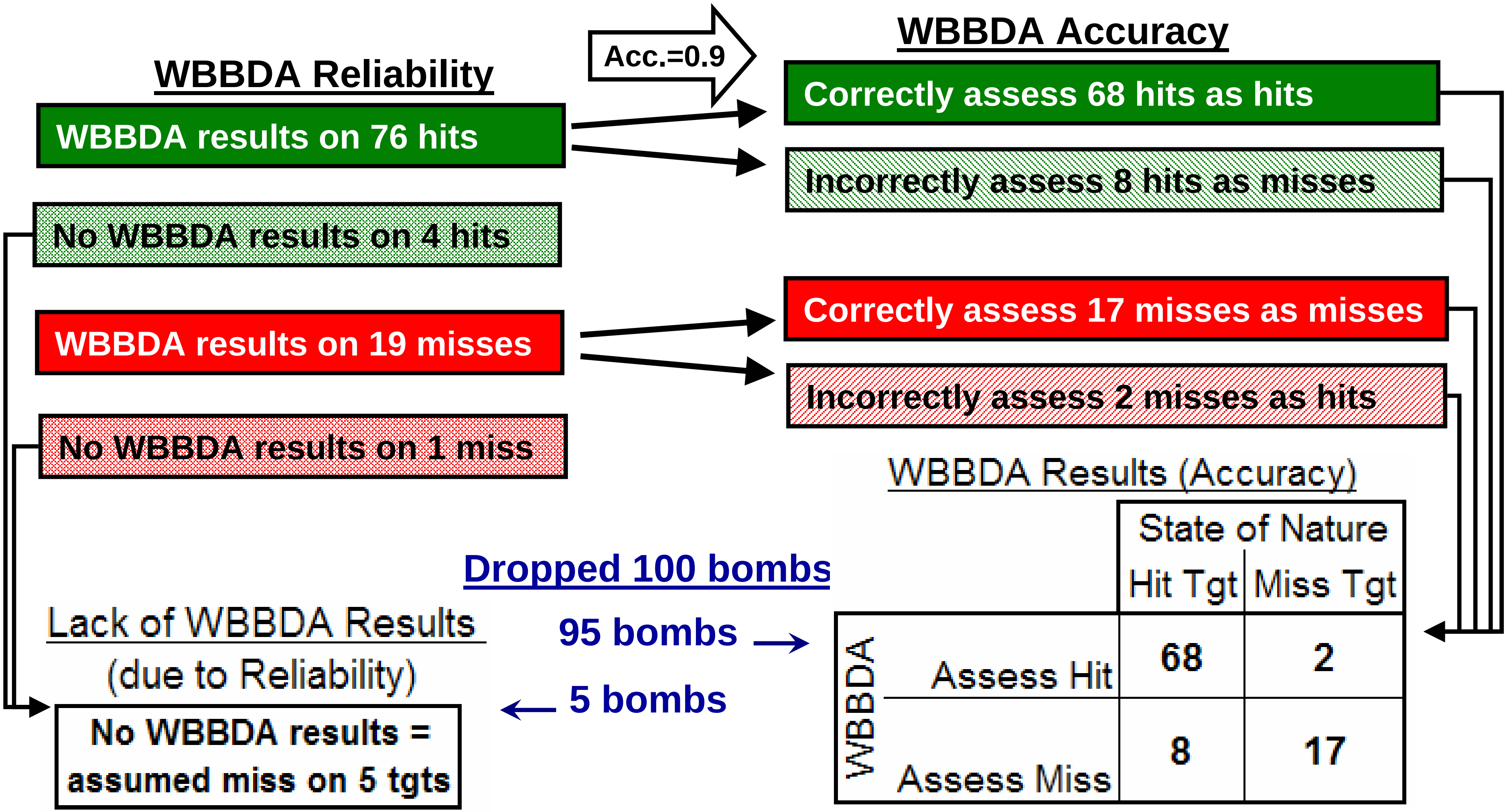
- **AS-IS**
  - **2 bombs / target, simultaneous**
  - **A/C RTB w/ 0 bombs**
- **TO-BE: WBBDA**
  - **1 bomb / target, repeat until WBBDA “hit”**
  - **A/C RTB w/ remaining bombs**
  - **Same # of targets, less bombs**
- **TO-BE: WBBDA + Doctrine (W+D)**
  - **DOT_LPF doctrine change (WBBDA + drop remaining bombs on additional/secondary tgts)**
  - **A/C RTB w/ no bombs**
  - **More targets, same # of bombs**

Single Package Model
Example

- **Drop 100 bombs on 100 targets**
- **Assume: P_k = 0.80, Reliability = 0.95, Accuracy = 0.90**



Single Package Model
Example (cont'd)



		State of Nature	
		Hit Tgt	Miss Tgt
WBBDA	Assess Hit	68	2
	Assess Miss	8	17

Single Package Model

Example - Targeting Implications

- **Results of 1st attack--implications to further targeting (P_k=.8, Rel.=.95, Acc.=.9)**

Drop 100 bombs

- WBBDA results on 95
- No WBBDA on 5

WBBDA Results

		State of Nature: Hit Tgt	State of Nature: Miss Tgt
WBBDA	Assess Hit	68	2
WBBDA	Assess Miss	8	17

Type I Errors
Retire targets
(targets survive)

Retire targets
(tgts destroyed)

Reattack targets
(all missed)

Type II Errors
Reattack targets
(all hit)

Lack of WBBDA Results

No WBBDA results =
assumed miss on 5 tgts

Reattack targets
(80% already destroyed)

Single Package Model
Example – Overall Results

- **Results after all reattacks (≤ 4 passes…100, 30, 5, 2)**
  - **Strike package departs with 100 WBBDA "hits"**
  - **Overall: 97 targets destroyed, 3 missed (Type I Errors)**

		State of Nature	
		Hit Tgt	Miss Tgt
WBBDA	Assess Hit	97	3 Type I
	Assess Miss	0 Type II	0

Single Package Model

Actual Results w/ Inputs at Baseline

INPUTS: Components WBBDA Effectiveness (all baseline)	μ	σ	
Weapon Pk	0.80	0.051	normal distribution

OUTPUTS

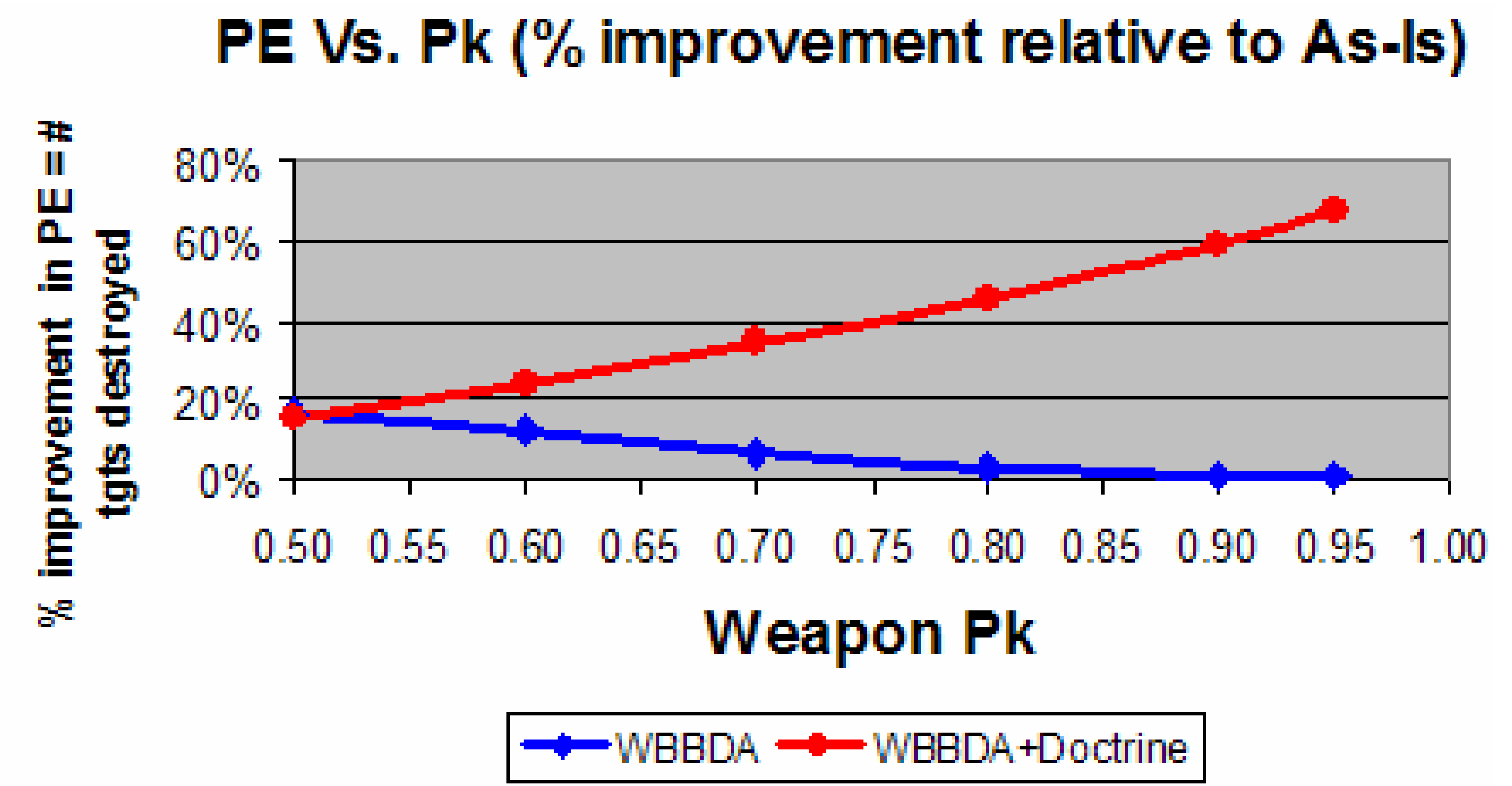
	As-Is		WBBDA			WBBDA w/ doctrine change		
	μ	σ	μ	σ	% improve in μ	μ	σ	% improve in μ
PPE (planned)	100	0.0	100	0.0	0.0%	145	0.0	45%
PE (destroyed)	95	2.1	98	1.0	2.4%	139	4.7	45%
AE (PE / PPE)	0.952	0.021	0.975	0.010	2.4%	0.956	0.032	0.3%
WPTK	2.10	0.04	1.41	0.09	-33%	1.42	0.09	-33%

WBBDA

WBBDA + Doctrine

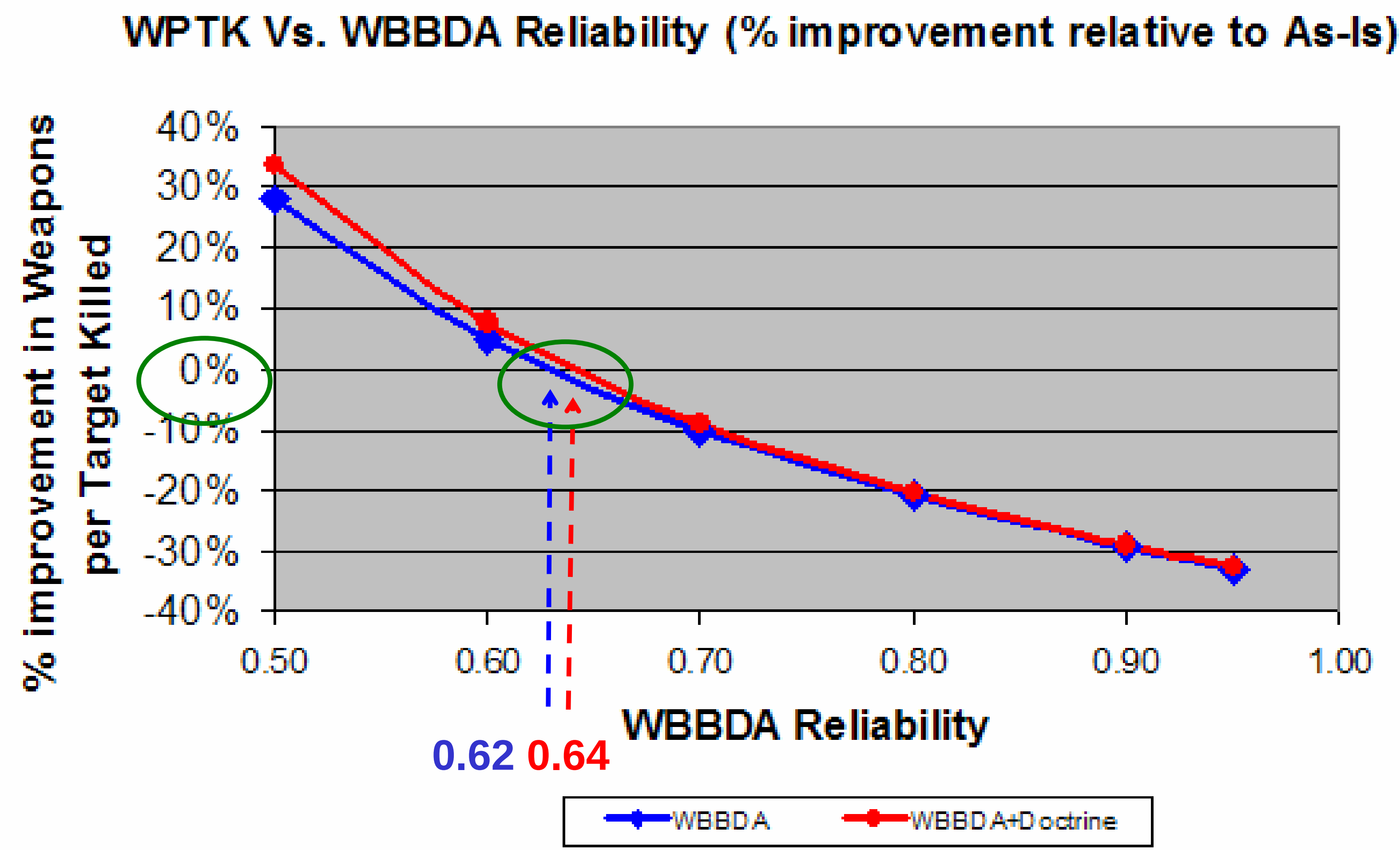
WBBDA capabilities improve on the AS-IS scenario

Single Package Model
Sensitivity to Weapon Pk



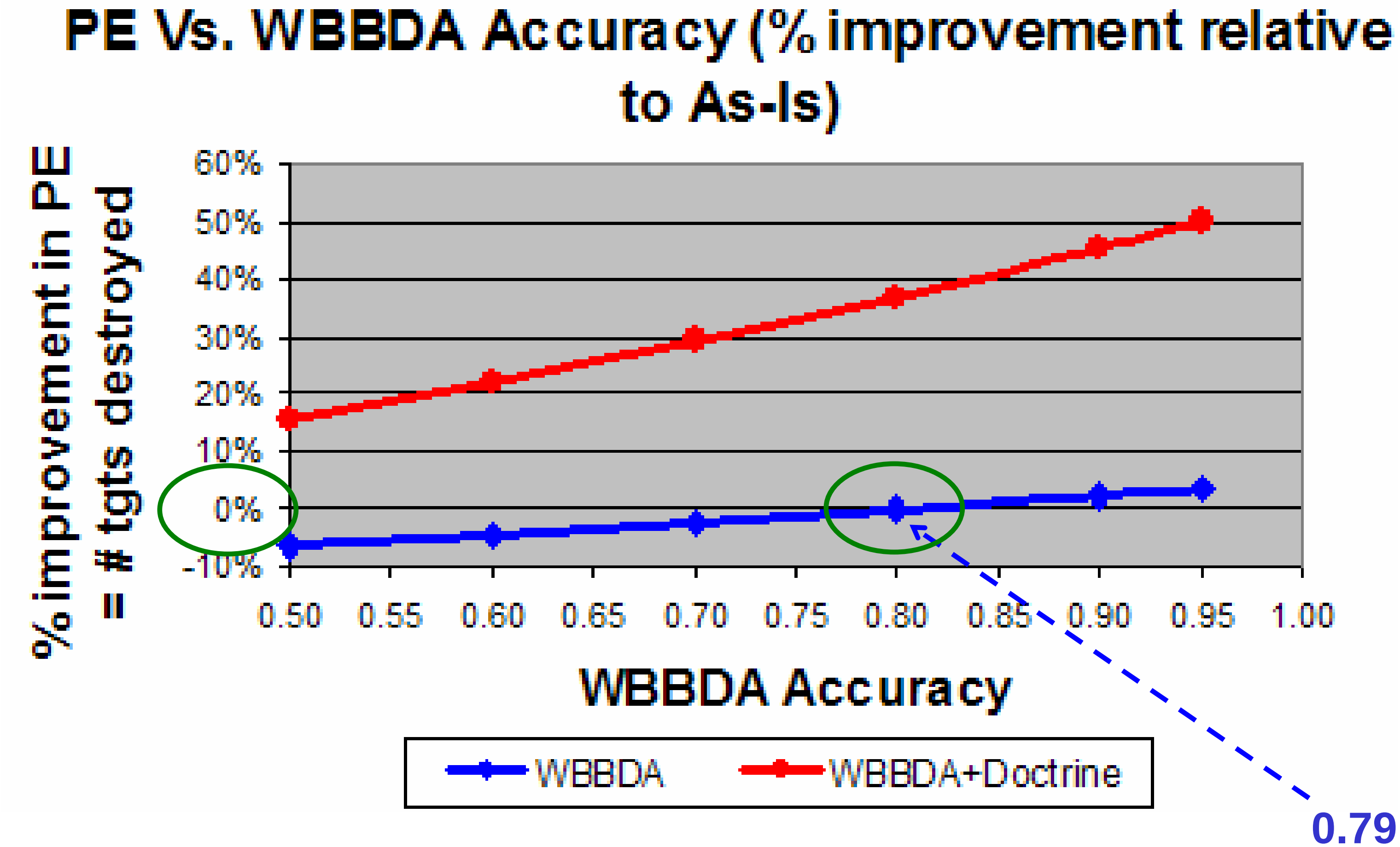
Strengthens argument to implement <u>doctrine change</u>

Single Package Model
Sensitivity to WBBDA Reliability



Supports establishment/study of a Reliability requirement

Single Package Model
Sensitivity to WBBDA Accuracy



Supports establishment/study of an Accuracy requirement

Single Package Model
Aircraft Loadout Comparison

- Does WBBDA capability favor either scenario?
  - More weapons per jet of lower P_k (SDB scenario)
  - Fewer weapons per jet of higher P_k (JDAM scenario)

	2,000# JDAM			250# SDB			500# JDAM		
	As-Is	WBBDA	W + D	As-Is	WBBDA	W + D	As-Is	WBBDA	W + D
# Tgts Destroyed	78	1.3%	54%	70	8.6%	33%	78	1.3%	54%
# Bombs Dropped	160	-34%	0%	160	-19%	-1%	160	-34%	0%
#Sorties Flown	80	0.0%	0%	20	0.0%	0%	40	0.0%	0%
Optimum # of Sorties	80	-34%	0%	20	-15%	0%	40	-33%	0%
Tgts Dest. / Opt. Sortie	0.975	52.9%	54%	3.5	27.7%	33%	1.95	50.0%	54%

Analysis of model results forced reconsideration of MOEs, architecture, and model

Architecture Based Evaluation Process (ABEP)

- **STEP 1: Design Ops Concept (OV-1) of System to be Evaluated**
- **STEP 2: Identify MOE's Relevant to the Decision/Evaluation**
- **STEP 3: Identify Required Level of Abstraction for Architecture to Show Traceability to MOE's**
- **STEP 4: Identify Architecture Views Necessary to Capture Structure/Relationships. NOT VIEWS, BUT DATA**
- **STEP 5: Develop Architecture Views NOT VIEWS, BUT DATA**
- **STEP 6: Modeling/ Simulation consistent with Architecture**
- **STEP 7: Evaluate Model Completeness**
- **STEP 8: Evaluate MOE**

Conclusion
ABEP vs DODAF

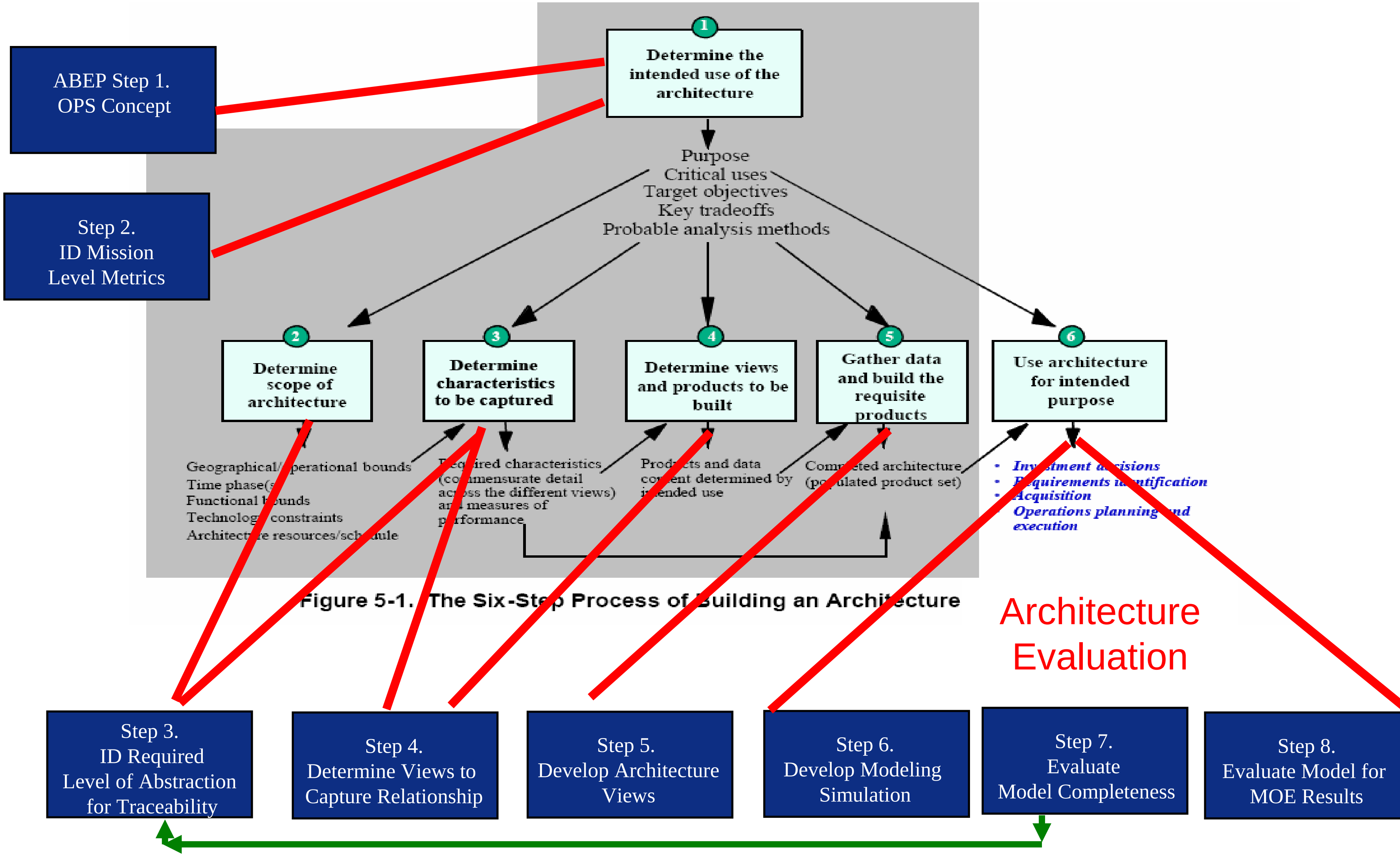
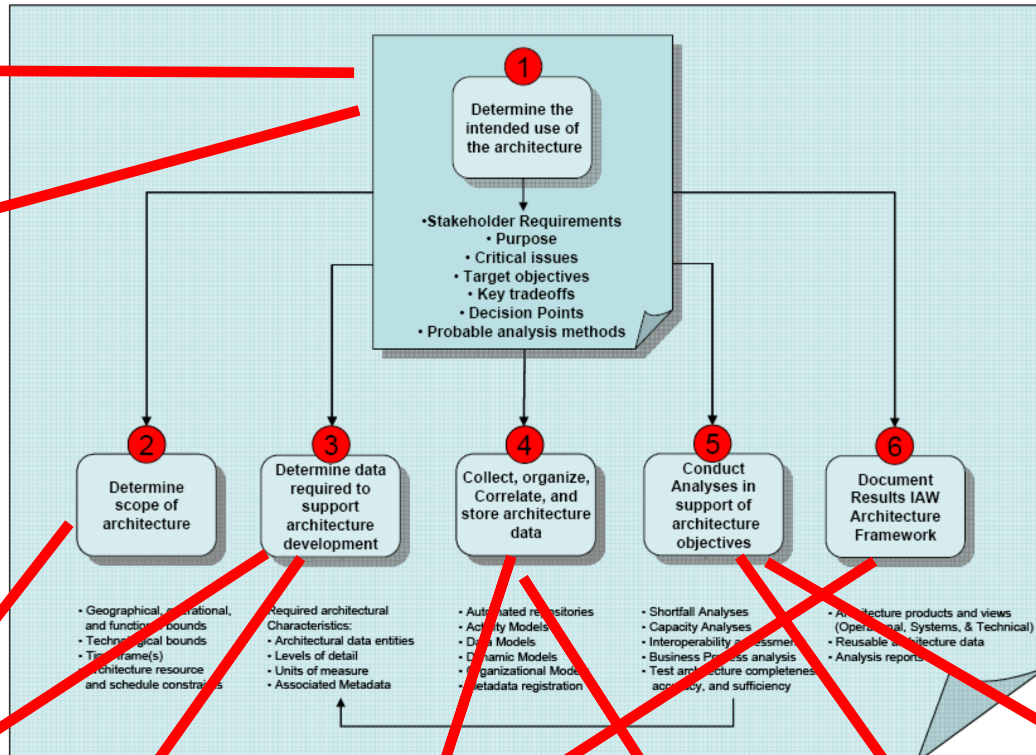


Figure 5-1. The Six-Step Process of Building an Architecture

6 Step DoDAF v1.5

ABEP Step 1.
OPS Concept

Step 2.
ID Mission
Level Metrics



Step 3.
ID Required
Level of Abstraction
for Traceability

Step 4.
Determine Views to
Capture Relationship

Step 5.
Develop Architecture
Views

Step 6.
Develop Modeling
Simulation

Step 7.
Evaluate
Model Completeness

Step 8.
Evaluate Model for
MOE Results

Conclusion

- WBBDA Specific
  - WBBDA + Doctrine Shift significantly increases MOE's
  - WBBDA Performance is sensitive to Accuracy, Reliability, & Pk
- Non-WBBDA Conclusions
  - Architecture can be used to effectively evaluate a system concept
  - Evaluate Gaps (FNA) and Evaluate Alternatives (FSA and AoA)
  - Identify Critical Requirements, KPP's
  - Provide Feedback for Architectural Changes & Emerging MOE's
- Process
  - Evaluation w/o Architecture = Inaccurate Evaluation, redundant effort, non-Concordance
  - Architecture w/o Evaluation = Static Architecture

Architecture can be used effectively to perform concept definition and analysis in support of JCIDS

System of Systems Implications for Operational Test

John Colombi, Ph.D
Dave Jacques, Ph.D

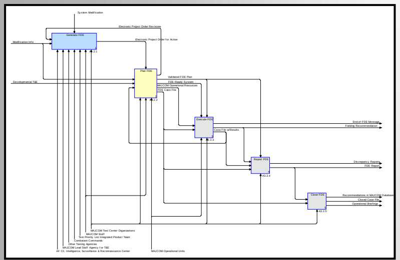
NDIA 10th Annual Systems Engineering Conference
22-25 Oct 07

Are we test planning differently in this DoD network-centric, system of systems environment?

Are we? Should we? Can we? How?

Agenda Roadmap

Policy



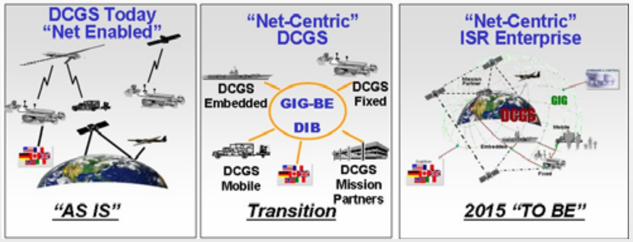
Process

Practice

7.1 Observations from Policy, Process, and Case Study Analysis

- *Observation 1: A Shift to Integrated, Capabilities-Based T&E Philosophy.* DoD and AF T&E policy reveals a philosophical shift from traditional platform-centric acquisition and testing to an integrated, capabilities-driven approach.
- *Observation 2: Seamless Verification Still Has Seams.* The prevalence of systems-of-systems and the evolution toward net-centric architectures demand T&E processes that are not only integrated throughout the lifecycle of a particular weapon system but are also integrated across entire sets of operational capability.
- *Observation 3: Apparent Lifecycle Seams Are Mitigated by Cooperation in the T&E Community.* Seamless verification, while a recent term, is not a new goal; the T&E community has a long-standing commitment to cooperative testing activities to achieve testing integrity and efficiencies in time, money, and resources.
- *Observation 4: Seams among Interdependent Systems Are Real.* While an ITT may provide a management structure for integrated testing across a system's lifecycle, ITTs aren't currently structured to integrate testing among interdependent systems.
- *Observation 5: Integration Is Not Built into the Process.* The AF's strategy of capabilities-based T&E relies heavily on the initiative of individual ITTs—vice a clearly delineated process—to integrate T&E, both in terms of a system's lifecycle and its interoperability in an SOS environment.
- *Observation 6: ACC's FDE Process Accommodates SOS Testing but Doesn't Deliberately Push in That Direction.* The process relies on the insight and foresight of action officers on ACC staff and FDE project officers at Test Center Organizations to properly scope FDEs to approximately demonstrate the full capabilities ACC is offering the warfighter.

AF DCGS



Net-Centric Ops

7.3 Implications of Net-Centric Operations for T&E

- *Implication 1: Co-evolution is Critical.* As the heralds of net-centricity emphasize, the DoD's transition from Industrial Age (platform-centric) to Information Age (net-centric) operations must include the co-evolution of supporting processes like T&E.
- *Implication 2: End-to-End Is Out and Net-Readiness Is In.* The emergence of net-centric architectures is making end-to-end assessments impractical. End-to-end assessments simply aren't scalable in a net-centric environment.
- *Implication 3: SOS T&E Requires SOS Acquisition and Sustainment.* SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating net-centric mission capabilities instead of individual systems.

7.2 Recommendations for AF DCGS

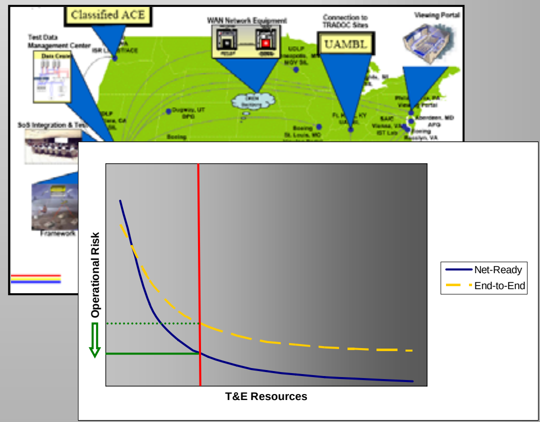
- *Recommendation 1.* Designate primary and alternate personnel (blue suit or contractor) to work AF DCGS T&E issues exclusively. ACC/A2YD will continue to serve as a critical "seam-bridger" between AF DCGS in sustainment and AF DCGS in modernization, and A2YD needs someone looking full time at T&E issues that span the system's lifecycle as well as its SOS partners.
- *Recommendation 2.* Develop a strong working relationship with A8X. The ACC FDE process is the "only game in town," and A2 needs to have a seat at the table as the process adapts to SOS and net-centric realities.
- *Recommendation 3.* Ensure A2 is on the October Call for Tests.
- *Recommendation 4.* Ensure A2 is part of coordination chain for the final TPL and all TPL/EPO revisions.
- *Recommendation 5.* Use the ACC FDE process. Work all AF DCGS FDE requirements through ACC/A8C and ensure the 605 TES is using EPOs to participate in AF DCGS T&E events.

User

Now

T&E

Future Attributes



Analysis | **Observations** | **Implications** | **Recommendations**

Background

- Operational concern:
  - Air Combat Command is “enterprise manager” for AF Distributed Common Ground Station (DCGS)
  - Test events being planned without coordination
  - T&E plans not validated
  - Missing opportunities to “piggy-back” test objectives


ISR Intelligence, Surveillance & Reconnaissance Journal

ISR Intelligence exploitation

Net-centric trailblazer

Services jointly pursue ‘Google’-like intelligence-sharing system

- Problem: AF not yet transitioned from system-centric to SOS approach to T&E

- Focus: ACC Force Development Evaluation (FDE) Process

- Methodology:
  - Policy and Guidance Review (Policy)
  - As-Is FDE Process (Process)
  - SYERS-2A Case Study (Practice)

"System of Systems" T&E

Cliché? No, a real problem

… a real research area

DAU Acquisiton Guidebook:

Defines System of Systems (SoS) as a set or arrangement of interdependent systems that are related or connected to provide a given capability.

SoS Characteristics (Maier 1996,1998)

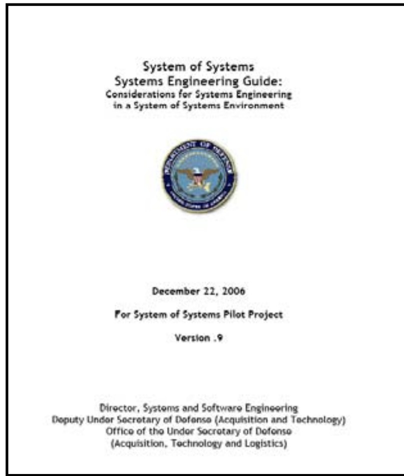
1. Operational Independence
2. Managerial Independence

Other Characteristics

Evolutionary Development

Emergent Behavior

Geographic Distribution

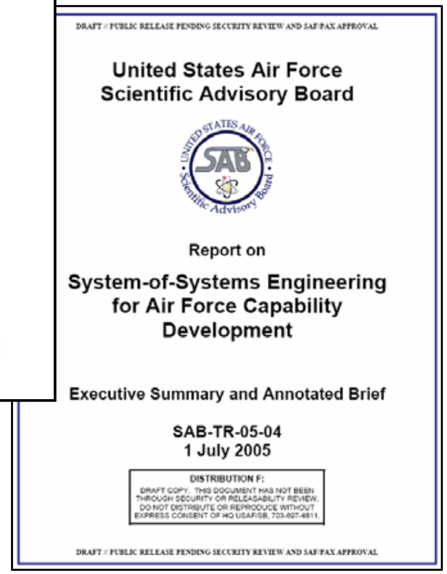

System of Systems
Systems Engineering Guide:
Considerations for Systems Engineering in a System of Systems Environment

December 22, 2006

For System of Systems Pilot Project

Version .9

Director, Systems and Software Engineering
Deputy Under Secretary of Defense (Acquisition and Technology)
Office of the Under Secretary of Defense
(Acquisition, Technology and Logistics)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United States Air Force
Scientific Advisory Board

Report on

System-of-Systems Engineering for Air Force Capability Development

Executive Summary and Annotated Brief

SAB-TR-05-04
1 July 2005

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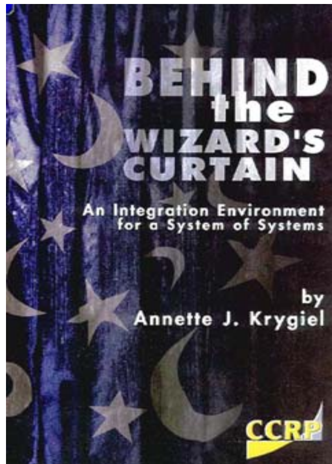

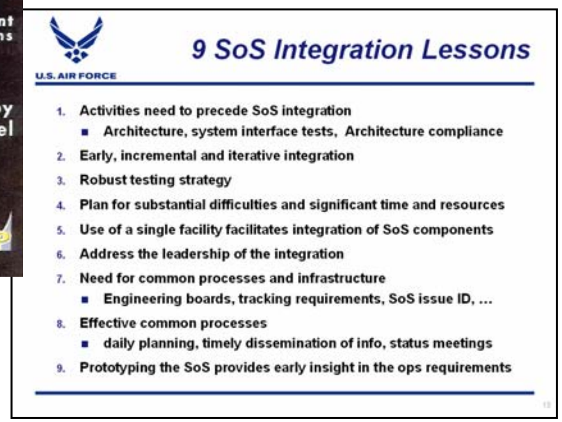
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9 SoS Integration Lessons

1. Activities need to precede SoS integration
   - Architecture, system interface tests, Architecture compliance
2. Early, incremental and iterative integration
3. Robust testing strategy
4. Plan for substantial difficulties and significant time and resources
5. Use of a single facility facilitates integration of SoS components
6. Address the leadership of the integration
7. Need for common processes and infrastructure
   - Engineering boards, tracking requirements, SoS issue ID, …
8. Effective common processes
   - daily planning, timely dissemination of info, status meetings
9. Prototyping the SoS provides early insight in the ops requirements

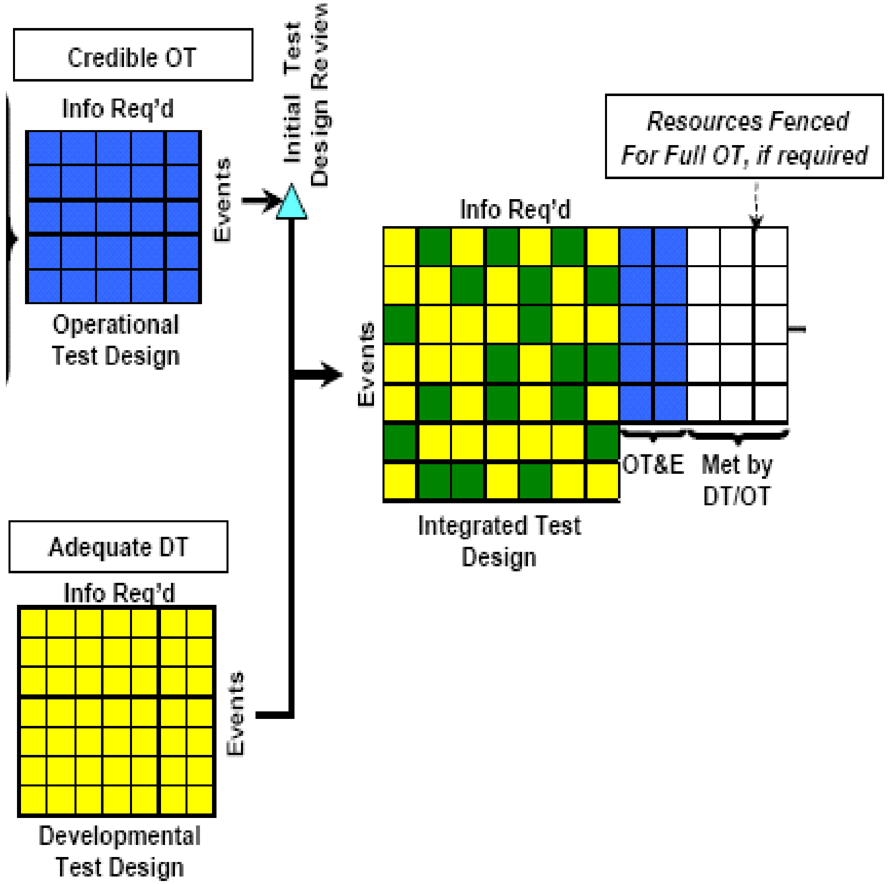
Test Policy/Guidance Review

- Public Law, DoD Policy
- AF Guidance
  - AF Policy Directive (AFPD) 99-1: T&E Process
  - AF Instruction (AFI) 99-103: Capabilities Based T&E
    - “Seamless Verification”
    - Integrated Test Team (ITT)
    - Common T&E Data Management (Open Database)
- Air Combat Command Instruction (ACCI) 99-101
- Other
  - Defense Acquisition Guide (DAG)
  - International Council on Systems Engineering (INCOSE)
  - ANSI/EIA-632

Test Policy/Guidance Review

- Air Combat Command Instruction (ACCI) 99-101: Test and Evaluation
  - Electronic Project Order (EPO)
  - Test Priority List (TPL)

- Others
  - AF T&E Guidebook
  - 53rd WG Test Team Handbook



DT + OT = Integrated Lifecycle Test Focus

SoS Test Guidance

- Defense Acquisition Guide (DAG) – Chapter 9

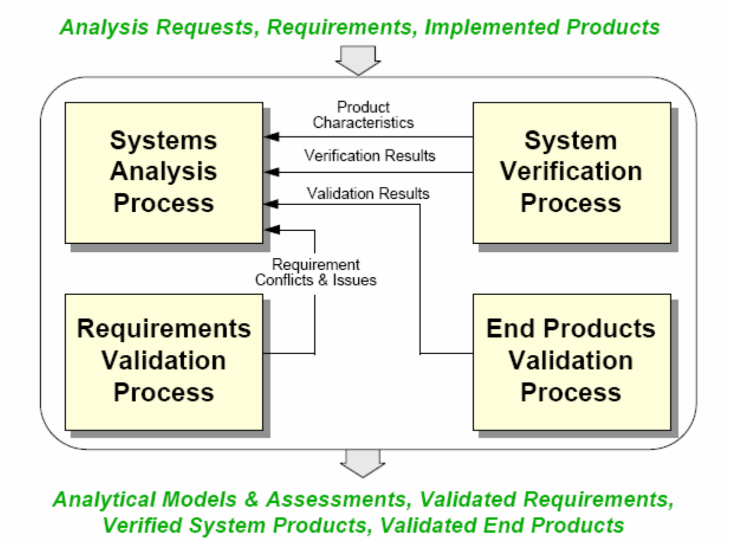
An important aspect is to develop a strategy for testing each system in the context of the system-of-systems, or family-of-systems architecture within which it is required to operate.

The shift away from point-to-point system interfaces to network-centric interfaces brings implications for the T&E community.

SoS Test Guidance Review

- INCOSE, Systems Engineering Handbook (ver 2a)
  - System Integration with External Interfaces
  - ICDs, Interface working Groups
  - Review test procedures and plans which verify these interfaces

- ANSI/EIA-632, Processes for Engineering a System
  - Technical Evaluation: Analysis, Verfication and Validation
  - Application Context
    - Enterprise Factors
    - Enterprise Support
    - External Factors
    - Other Enterprise Projects



Air Force Test Policy

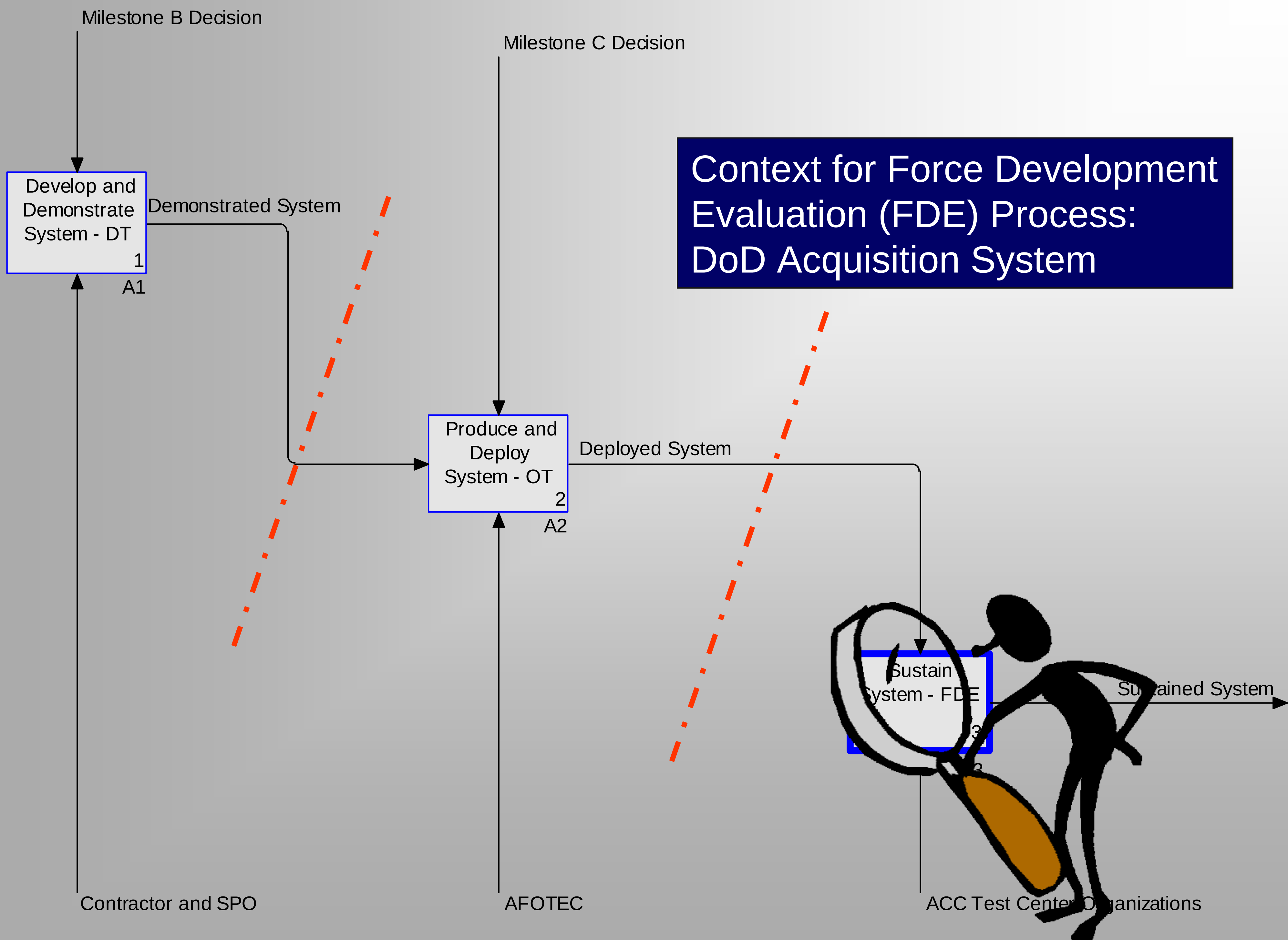
- ***Observation 1:***

  A Shift to Integrated, Capabilities-Based T&E

- ***Observation 2:***

  Seamless Verification Still Has Seams

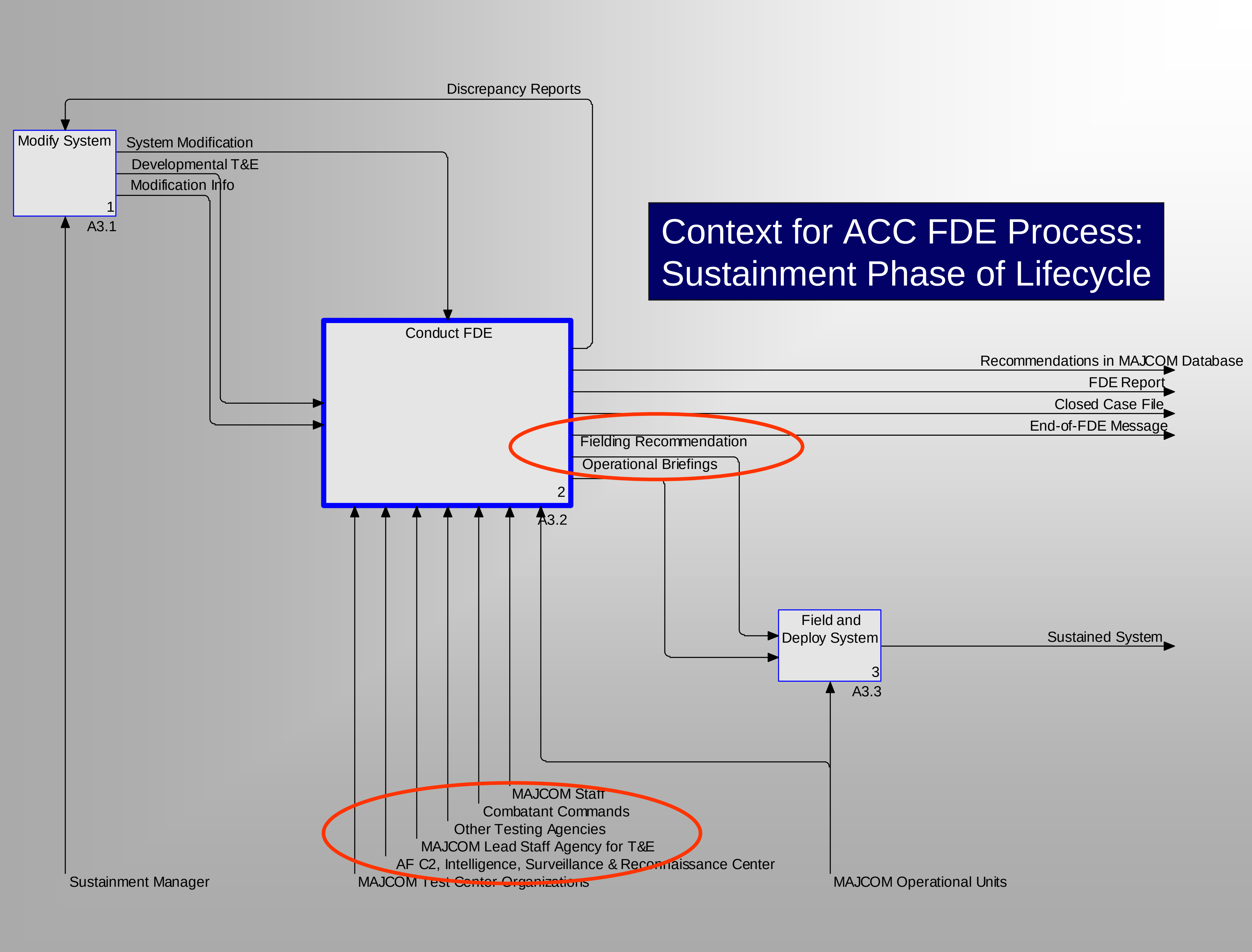
Context for Force Development Evaluation (FDE) Process: DoD Acquisition System



Force Development Evaluation (FDE)

- A Subset of Operational Test and Evaluation (OT&E)

- *Demonstrate the operational effectiveness and suitability of a system as evolutionary upgrades are made to sustain its relevance*


Context for ACC FDE Process:
Sustainment Phase of Lifecycle
Discrepancy Reports
Modify System
1
A3.1
System Modification
Developmental T&E
Modification Info
Conduct FDE
2
A3.2
Recommendations in MAJCOM Database
FDE Report
Closed Case File
End-of-FDE Message
Fielding Recommendation
Operational Briefings
Field and
Deploy System
3
A3.3
Sustained System
MAJCOM Staff
Combatant Commands
Other Testing Agencies
MAJCOM Lead Staff Agency for T&E
AF C2, Intelligence, Surveillance & Reconnaissance Center
MAJCOM Test Center Organizations
Sustainment Manager
MAJCOM Operational Units

FDE Process Observations

- ***Observation 3:***

  Apparent Lifecycle Seams are Mitigated by Cooperation in the T&E Community

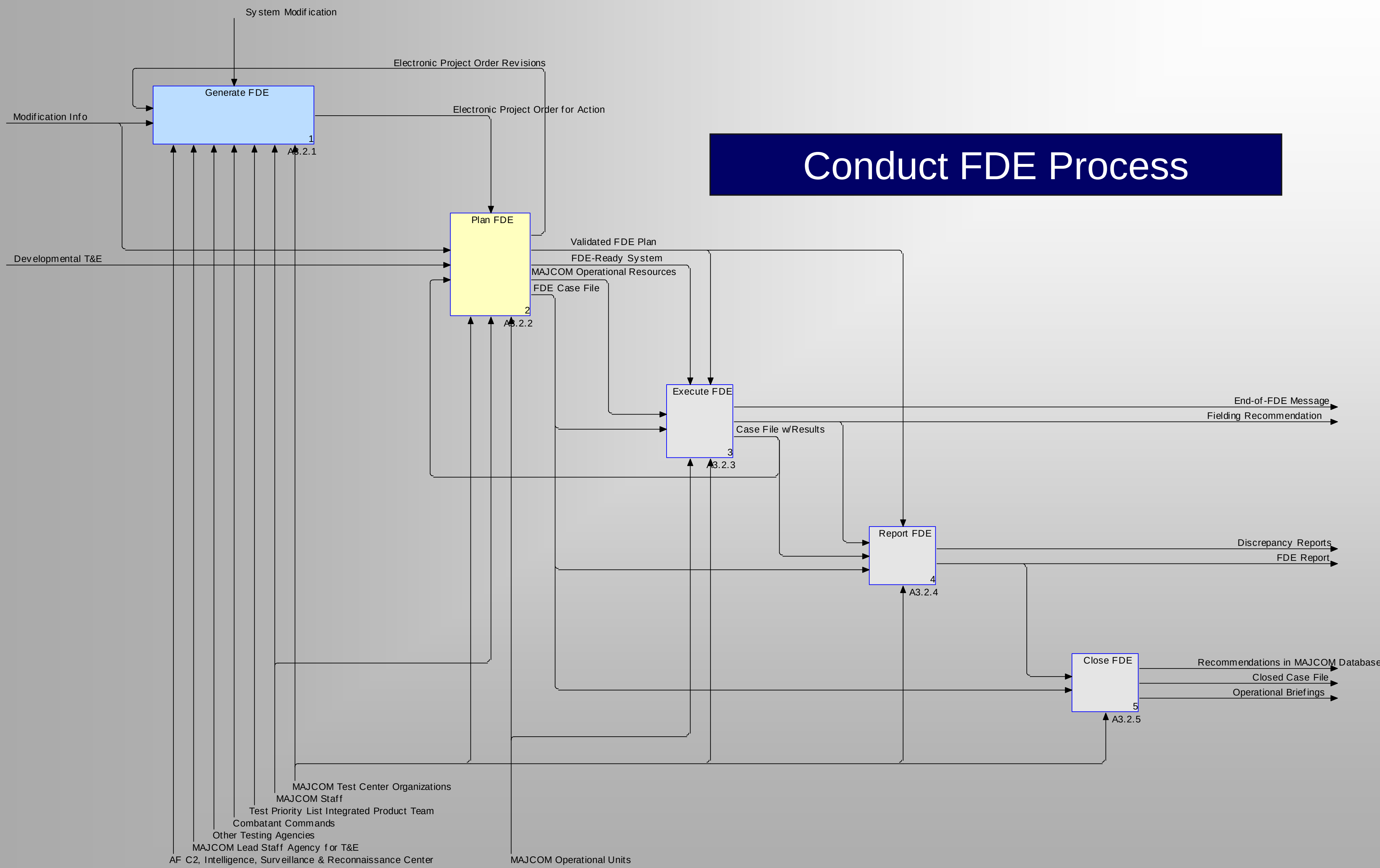
- ***Observation 4:***

  Seams Among Interdependent Systems are Real

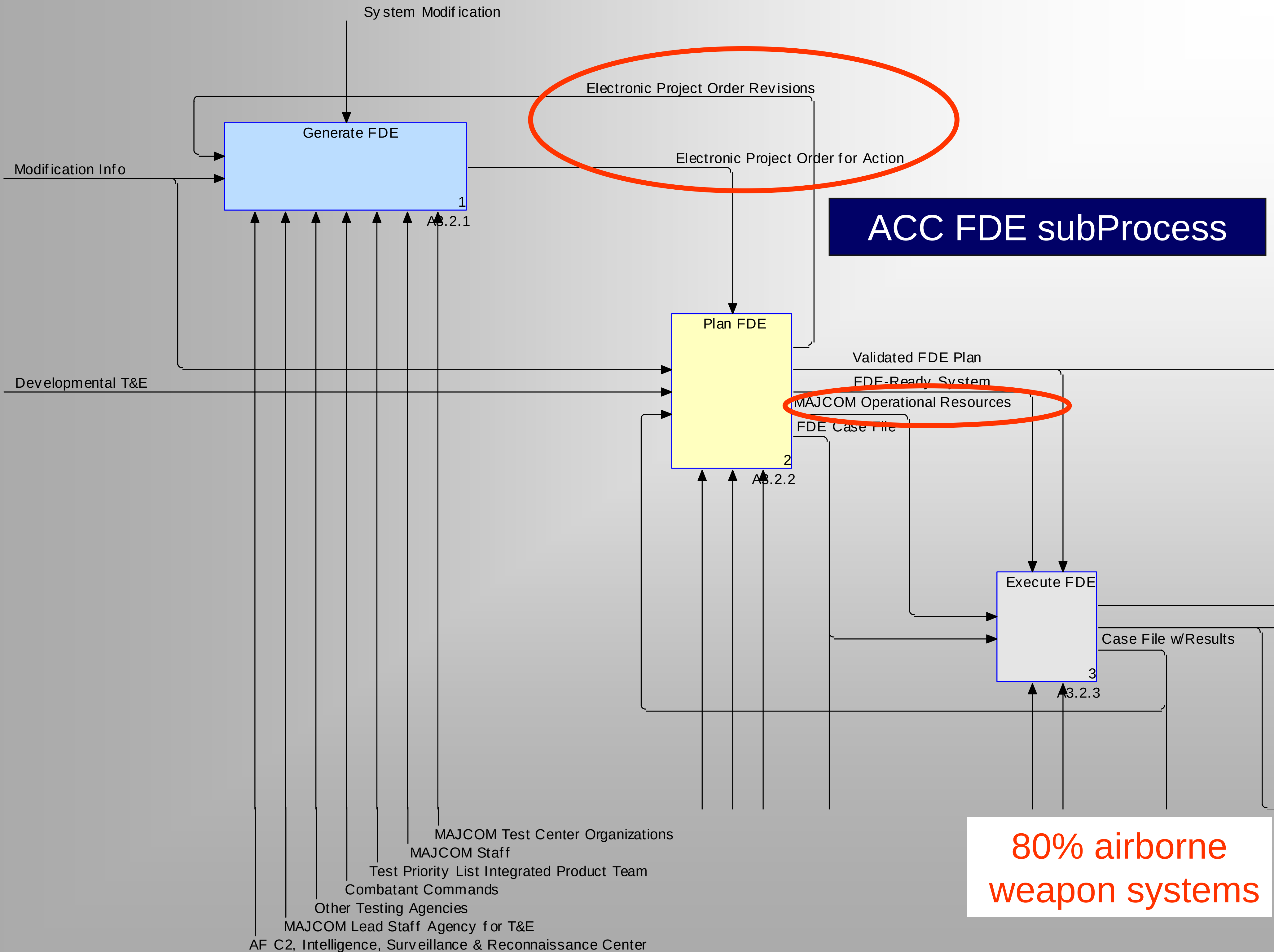
- ***Observation 5:***

  Integration is NOT Built Into the Process

Conduct FDE Process



ACC FDE subProcess



80% airborne weapon systems

FDE Process Observations

- ***Observation 6:***

  FDE Process Accommodates SOS Testing But Doesn’t Deliberately Force it

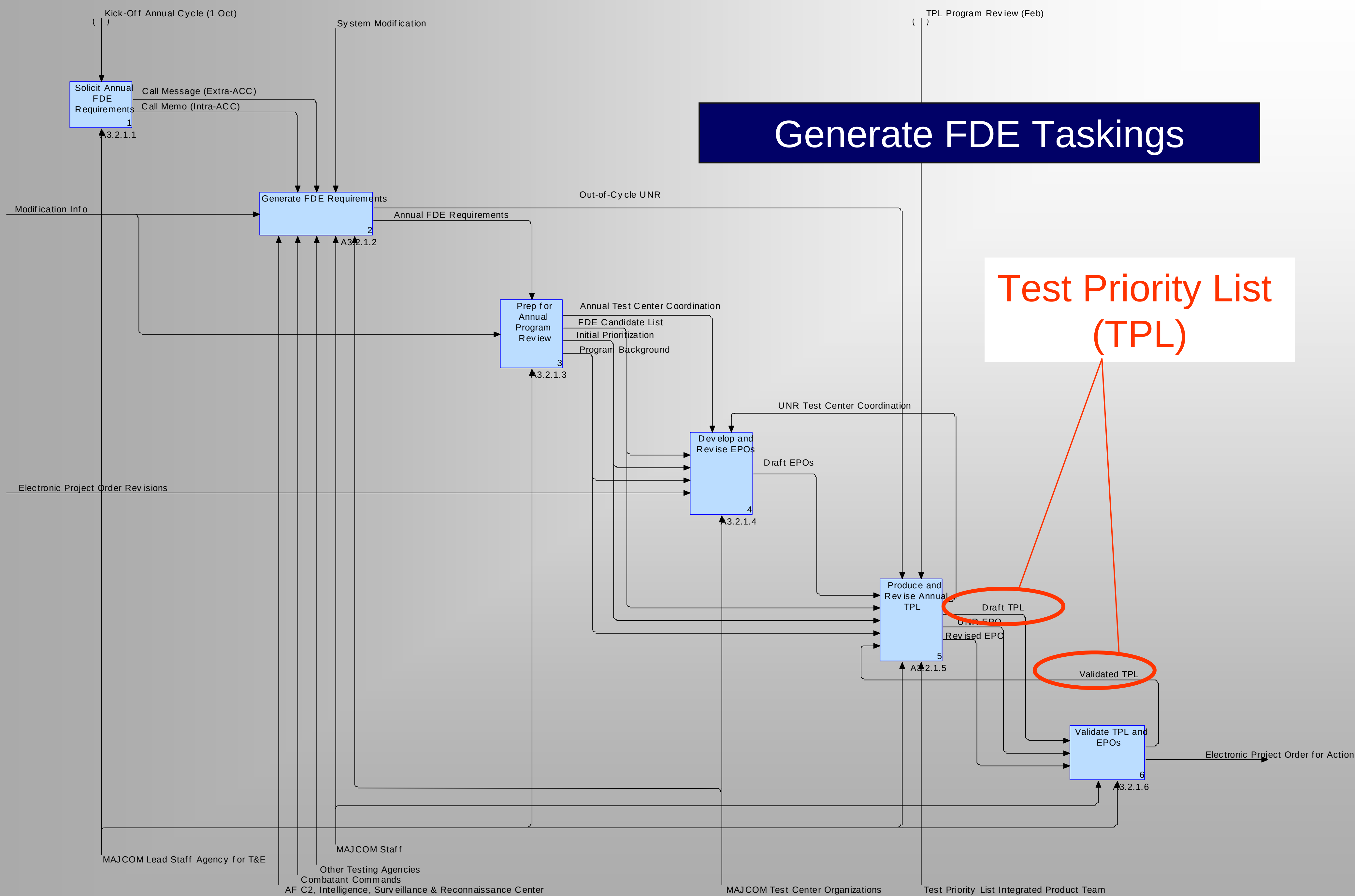
- ***Observation 7:***

  Resource Constraints Limit ACC’s Ability to Develop SOS FDEs

- ***Observation 8:***

  Process is Beginning to Embrace Non-Traditional Weapon Systems

Generate FDE Taskings



FDE Process Observations

- ***Observation 9:***

  Increasing Load on the FDE Process

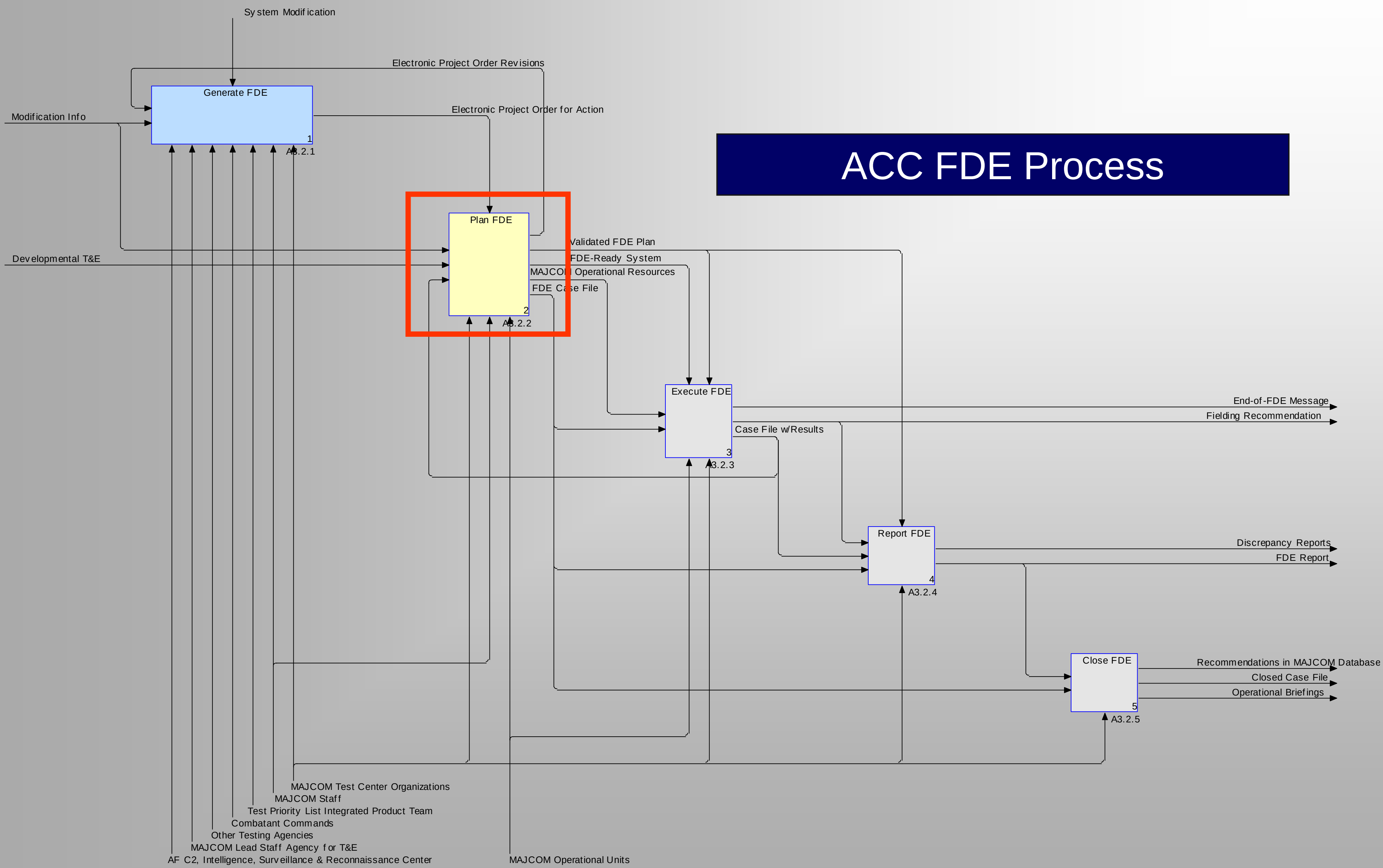
DoD T&E Summit 2004, Dr. Glenn Lamartin:

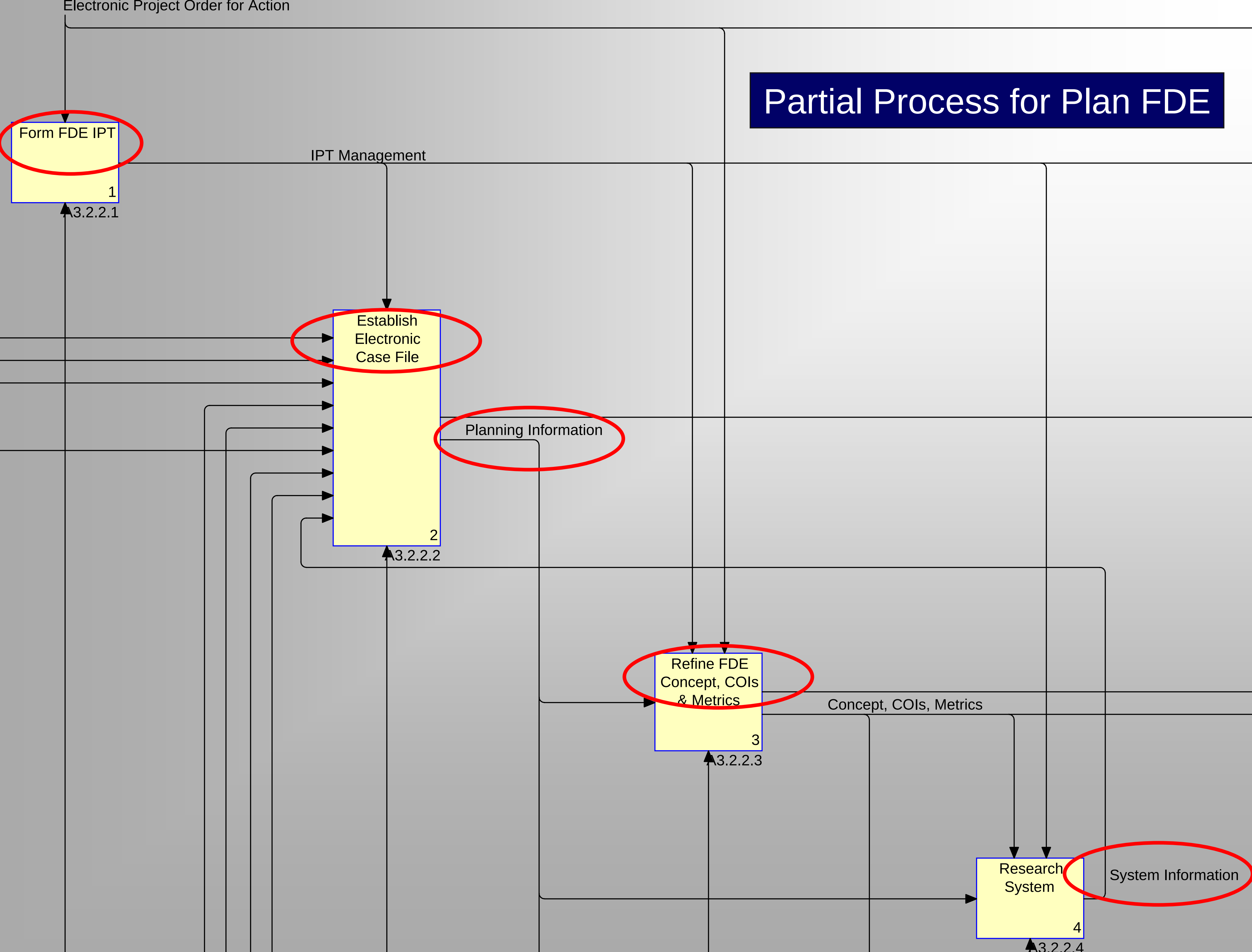
- *From platforms to capabilities & SOS solutions*
- *Increasing complexity and interdependencies of systems*
- *Exponential growth in interfaces (network participants)*
- *Increased requirements for T&E (Evolutionary Acq)*

NCW, Alberts, Garstka and Stein

"Testing systems will become far more complex since the focus will not be on the performance of individual systems by on the performance of the federation of systems"

ACC FDE Process




Electronic Project Order for Action
Partial Process for Plan FDE
Form FDE IPT
1
A3.2.2.1
IPT Management
Establish Electronic Case File
2
A3.2.2.2
Planning Information
Refine FDE Concept, COIs & Metrics
3
A3.2.2.3
Concept, COIs, Metrics
Research System
4
A3.2.2.4
System Information

FDE Process Observations

- ***Observation 10:***

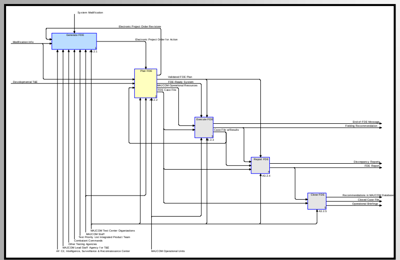
  Test Center Project Manager (PM) is the Key Actor in FDE Planning

- ***Observation 11:***

  Lack of AF-Level Guidance on T&E Information Management

Agenda Roadmap

Policy



Process

Practice

7.1 Observations from Policy, Process, and Case Study Analysis

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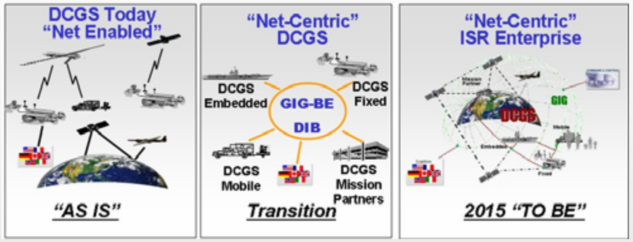
AF DCGS



Net-Centric Ops

7.3 Implications of Net-Centric Operations for T&E

- *Implication 1: Co-evolution is Critical.* As the heralds of net-centricity emphasize, the DoD's transition from Industrial Age (platform-centric) to Information Age (net-centric) operations must include the co-evolution of supporting processes like T&E.
- *Implication 2: End-to-End Is Out and Net-Readiness Is In.* The emergence of net-centric architectures is making end-to-end assessments impractical. End-to-end assessments simply aren't scalable in a net-centric environment.
- *Implication 3: SOS T&E Requires SOS Acquisition and Sustainment.* SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating net-centric mission capabilities instead of individual systems.

7.2 Recommendations for AF DCGS

- *Recommendation 1.* Designate primary and alternate personnel (blue suit or contractor) to work AF DCGS T&E issues exclusively. ACC/A2YD will continue to serve as a critical "seam-bridger" between AF DCGS in sustainment and AF DCGS in modernization, and A2YD needs someone looking full time at T&E issues that span the system's lifecycle as well as its SOS partners.
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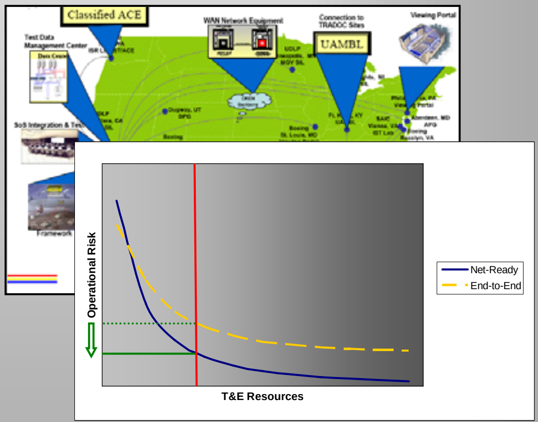
User

Now

T&E

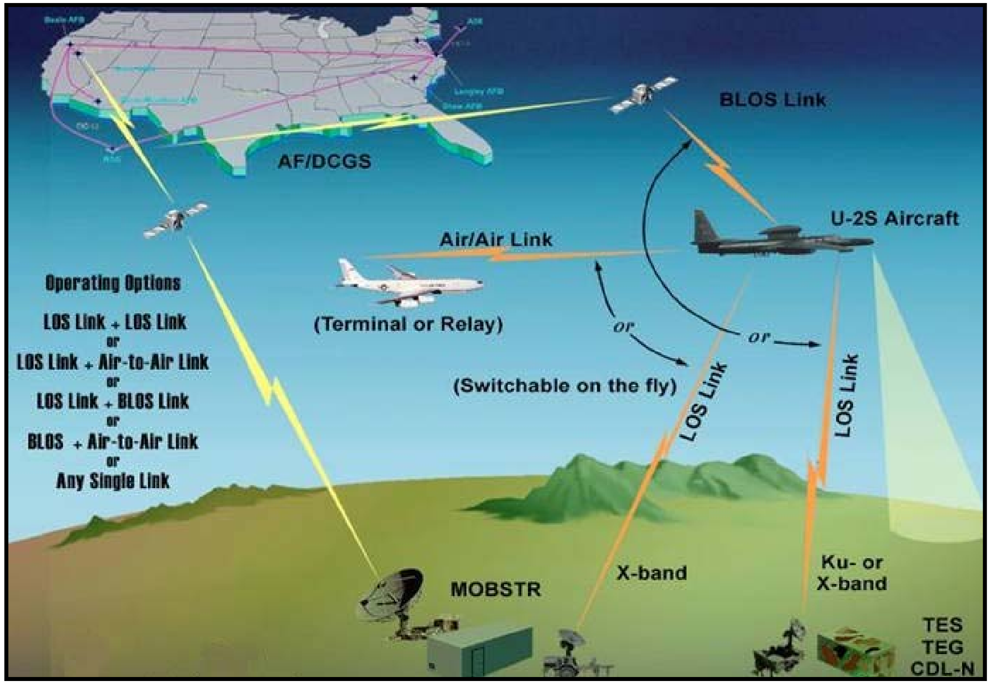
Future Attributes



Analysis | **Observations** | **Implications** | **Recommendations**

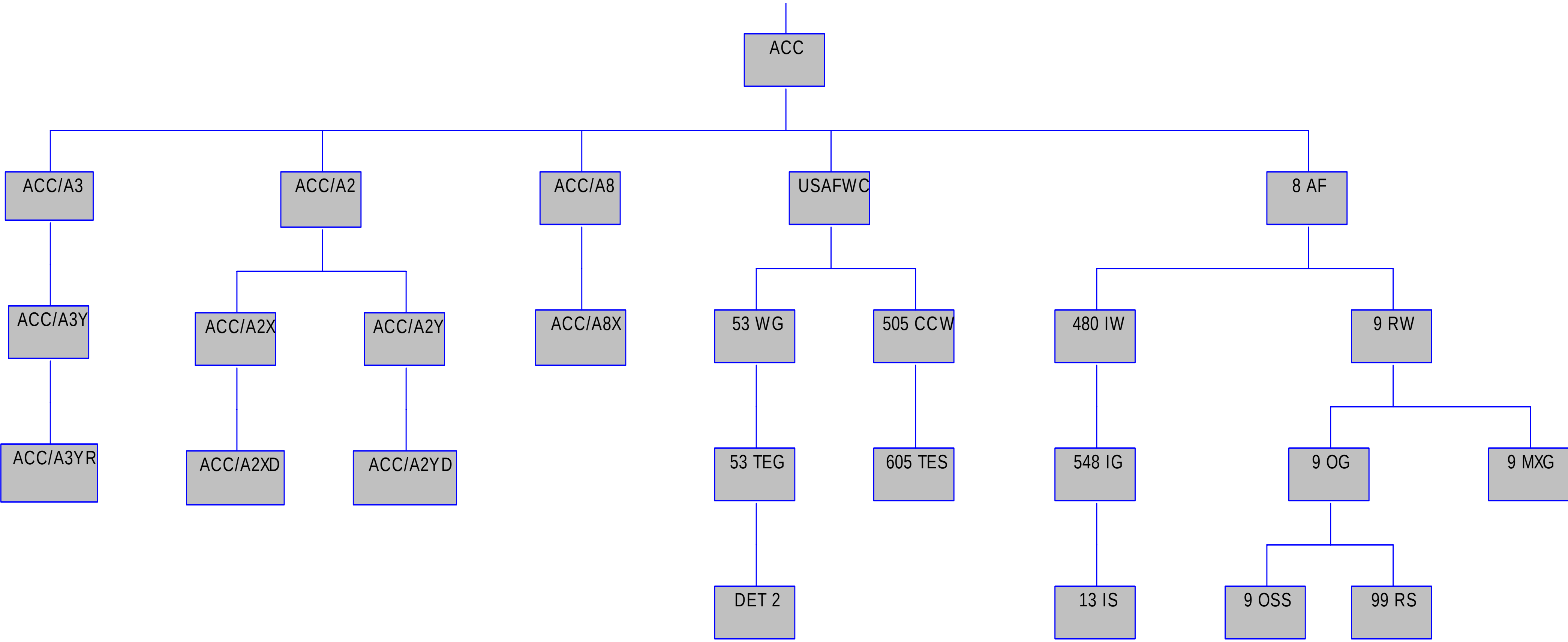
Sensor Case Study

- Platform: U-2S - high altitude surveillance & reconnaisscance
- Sensor: SYERS-2A - multispectral (EO/IR) imaging sensor
  - Upgrade to airborne processor with ATM interface
- Data Link: Dual Data Link 2 (DDL 2-LOS and BLOS configurations
- Ground Station: AF DCGS - dispersed ground systems supporting first-phase analysis of U-2, Predator, Global Hawk and other sensors via secure WAN



Numerous Stakeholders

… an insightful OV-4



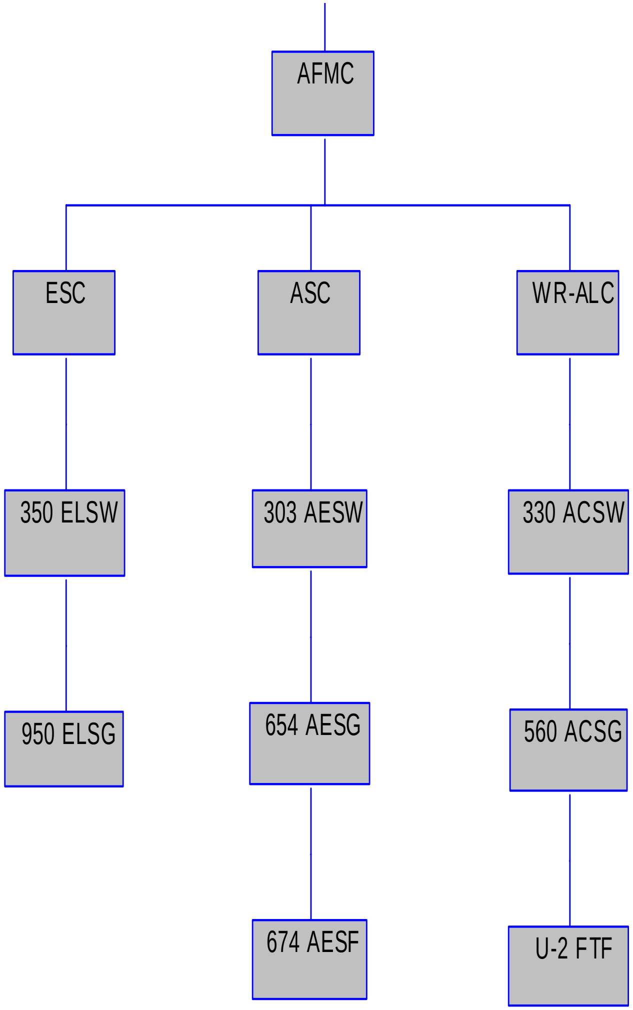
Enterprise Management
Requirements
Test Resourcing
Test Coordination

Test Planning
Test Execution
Airborne and C2

Operations
Air and Ground

…Numerous Stakeholders

… an insightful OV-4



DCGS Sustainment (O&M)

U-2 Sustainment (O&M)

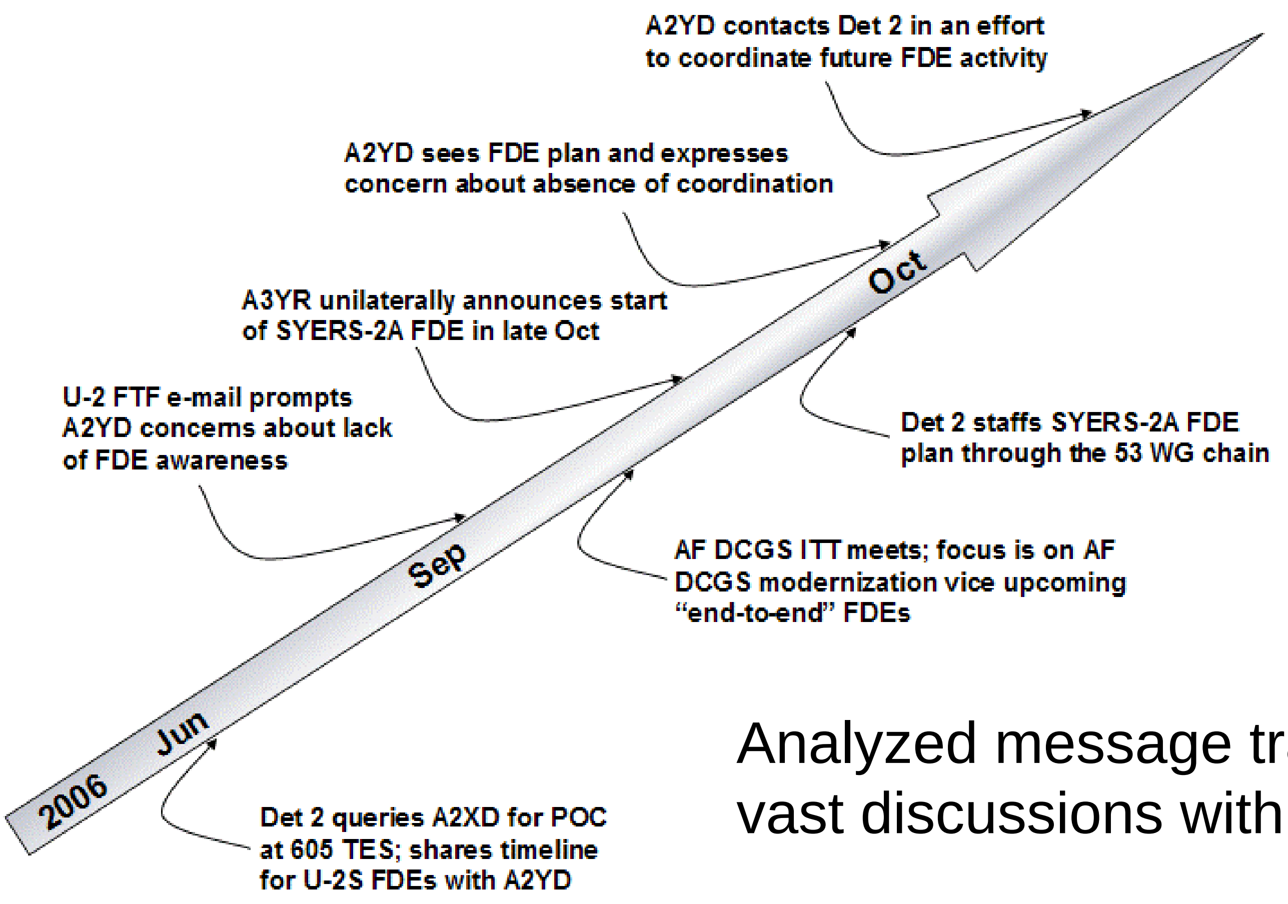
DCGS System Program Management
New Acquisition and Modernization

U-2 System Program Management
New Acquisition and Modernization

Flight Test Facility

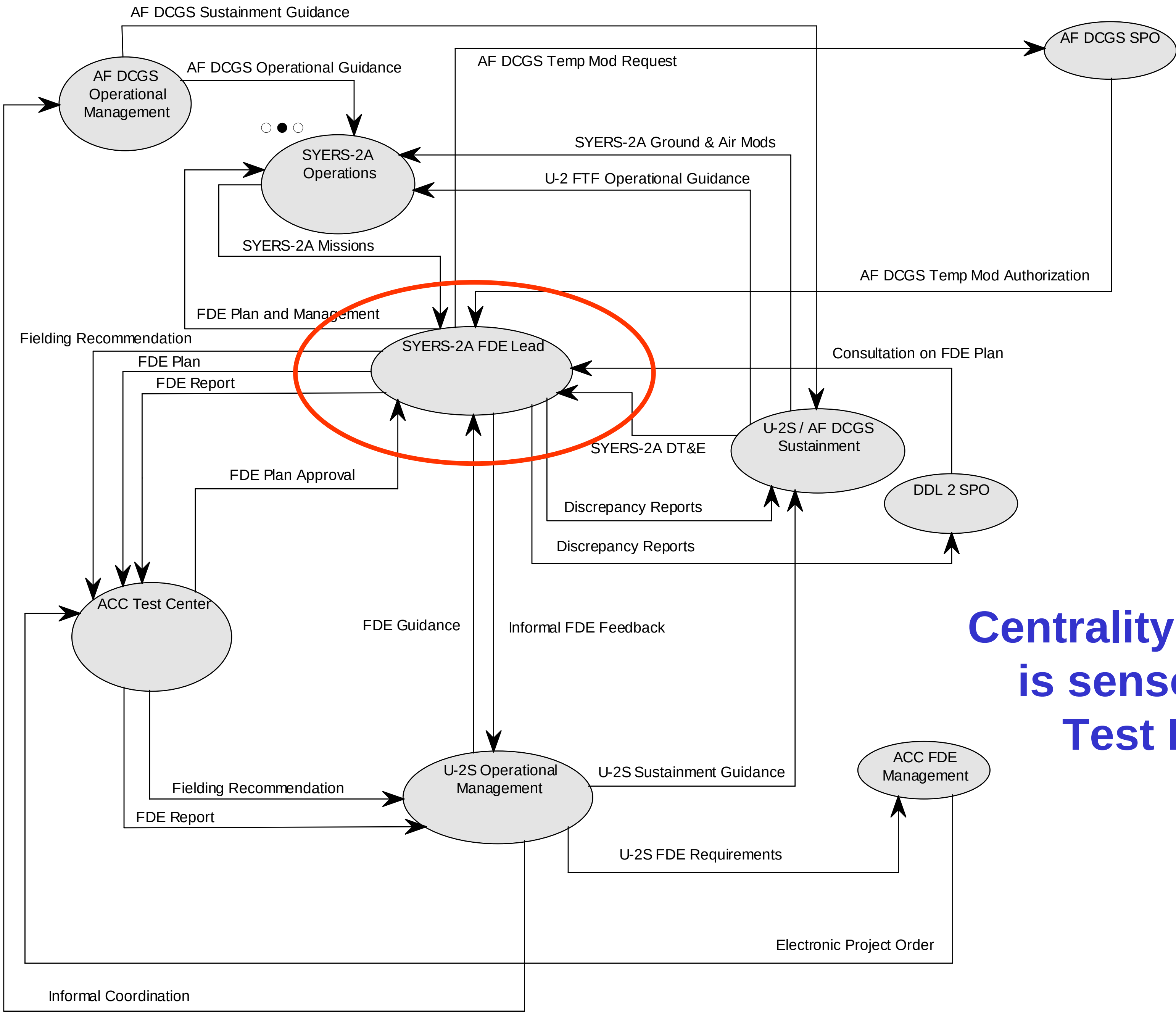
Sequence of Events

Test Objective: "Verify SYERS-2A sensor end-to-end operations and to demonstrate full airborne/ground segment functionality with DLL2 in available configurations and operational representative architectures"



Analyzed message traffic, documents, and vast discussions with SME/ POCs

Complex Interactions



Centrality of graph is sensor FDE Test Lead

Case Study Observations

- ***Observation 12:***

  Program Priorities Dominate Even Among Interdependent Systems

- ***Observation 13:***

  System-Centric Management

- ***Observation 14:***

  System Focus for the Fielding Decision

- ***Observation 15:***

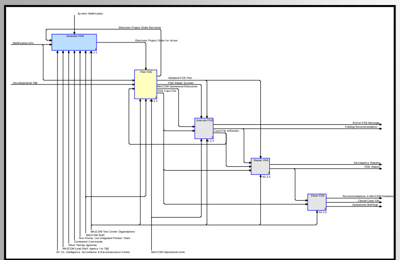
  Some Coordination Tools Left Unused

- ***Observation 16:***

  Ability to Define the “Ends” Disappearing as Net-Centric Reality Emerges

Agenda Roadmap

Policy



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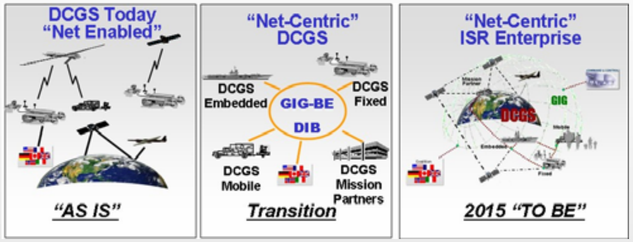

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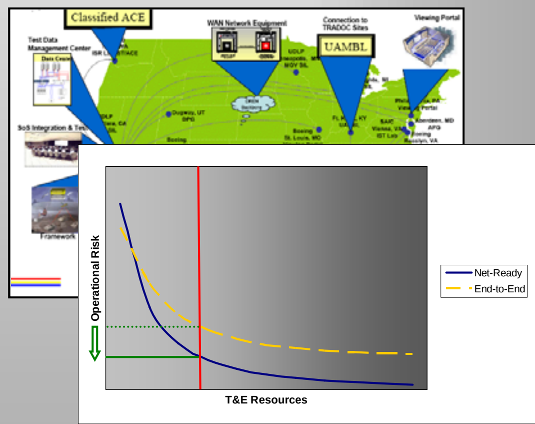
Now → **User**

Future Attributes → **T&E**



Analysis | **Observations** | **Implications** | **Recommendations**

Implications for T&E

Implication 1: Co-evolution Is Critical

> Exposure to new information technologies and their capabilities is potentially dangerous unless it is accompanied by changes in a number of key dimensions.
>
> - Alberts, *Information Age Transformation*

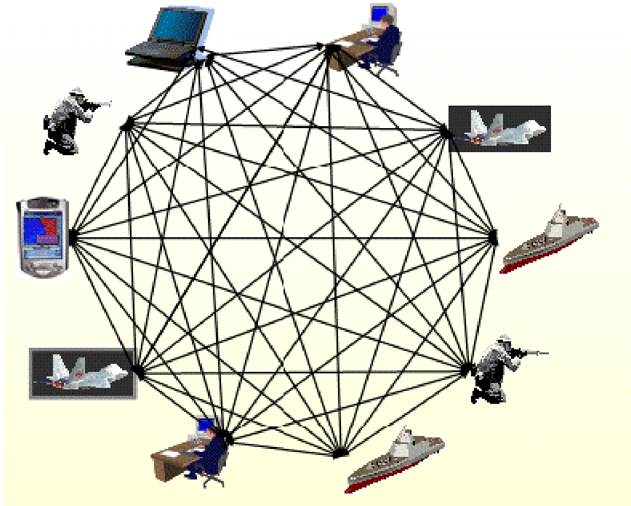
Doctrine

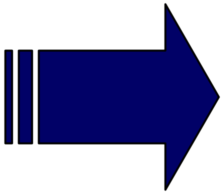
Training & Education

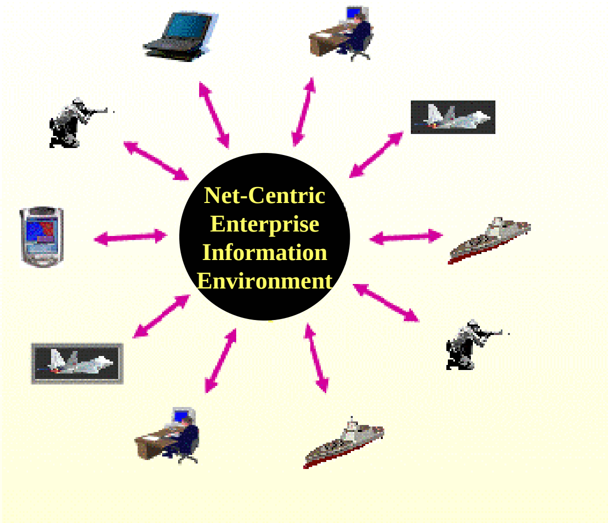
<u>Test & Evaluation</u>

Implications for T&E

Implication 2: End-to-End Is Out, Net-Ready Is In

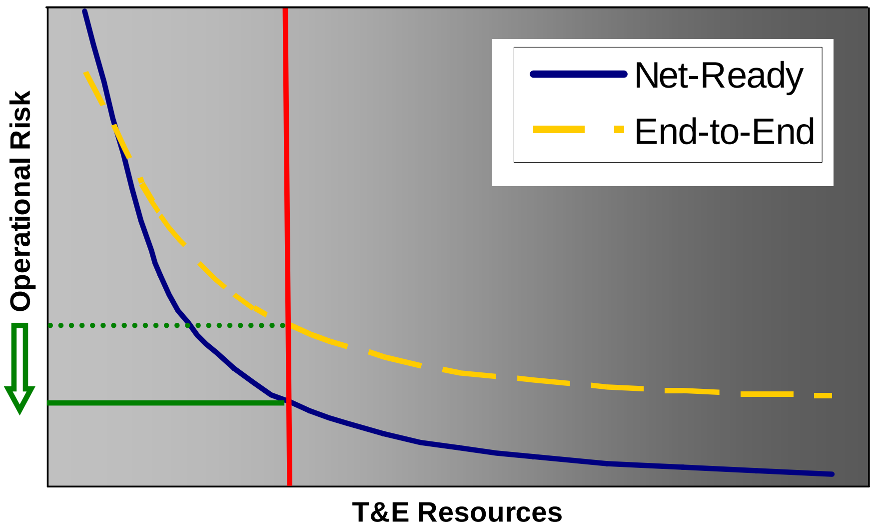






Focus of test and evaluation needs to shift from the performance of individual entities to their ability to add value to the networked force.

- Alberts, *Information Age Transformation*



Implications for T&E

Implication 3: SOS T&E Can't Work Alone

SOS T&E should complement a strategic planning, budgeting, requirements development, and acquisition system fundamentally oriented toward generating enterprise/mission capabilities instead of individual systems.

Recommended Characteristics for future SoS FDE

1. Scope to Validate Operational Capabilities
   - How? Use DoDAF Products/ M&S to understand complex relationship of systems and capabilities
2. Use Net-Readiness Objectives to Validate SoS Interoperability
   - How? Use DoD Net-Centric Data Strategy:

Visible	Trusted
Agile	Responsive
Accessible	Understandable

3. Prioritize According to Operational Risk
4. Employ appropriate Integration Environments

Conclusion

- Policy and guidelines now reflect the changing IT landscape of system of systems.
  - Integrated T&E and Seamless Verification
- Leaders have predicted this changing landscape will directly impact T&E activities
- Lessons can be learned from enterprise case studies
- Many organizations/ enterprises may rely on the heroics of system-level test managers to handle this added SOS focus

Changes to Integration, Test and Evaluation in a network-centric SoS environment is imperative

Case Studies: A Common Language Between Engineers and Managers

10th Annual NDIA Systems Engineering Conference

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The views expressed in this presentation are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.

Overview

- Background
  - Communication Facilitation
  - Engineering training and education
  - Manager training and education
- Possible Discourse Problems
- Example Case Studies
  - Surface Assessment Robot
  - Autonomous Helicopter
- Observations & Pitfalls Experienced

Background

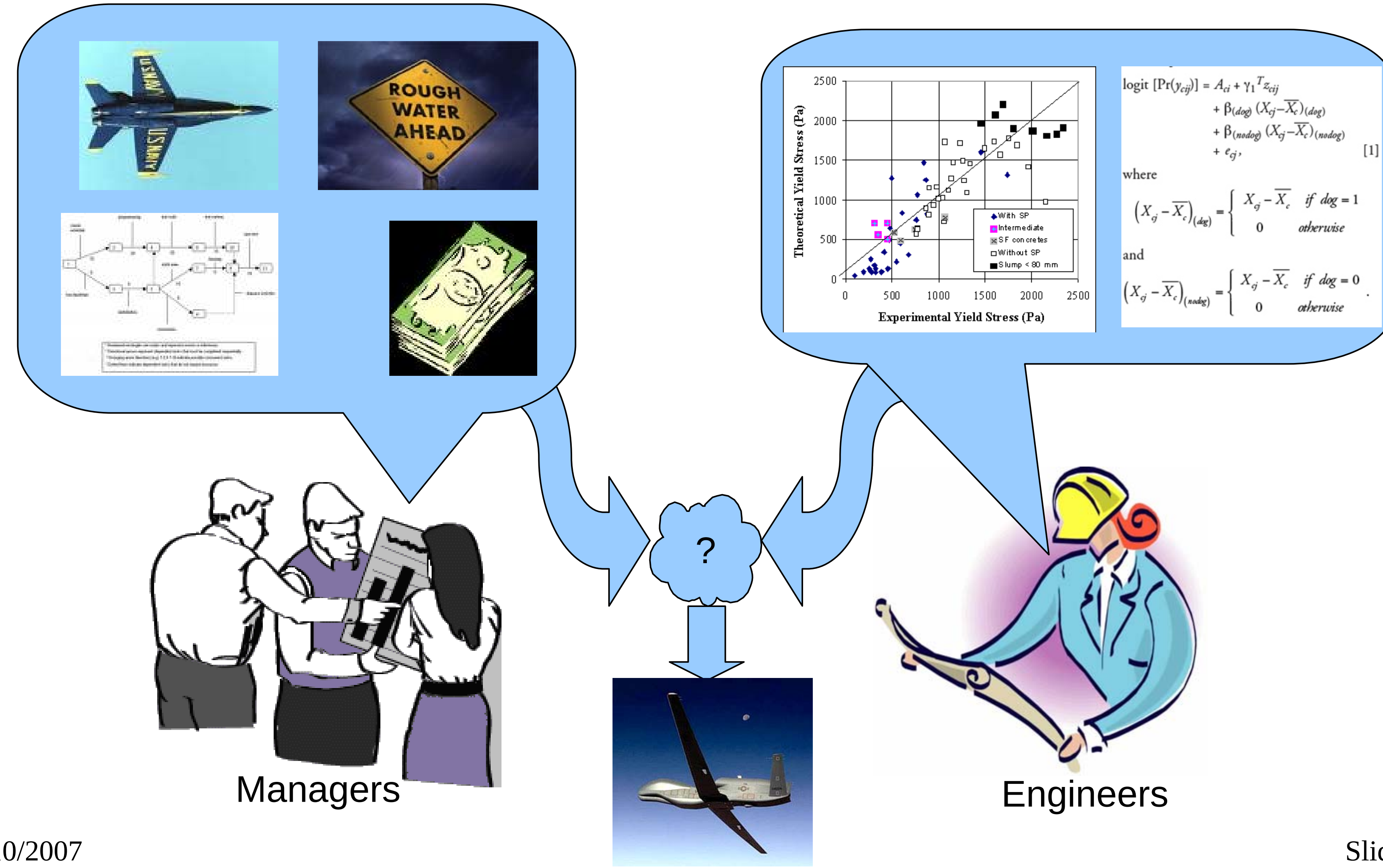
- Review communications basics – where would discourse about cases help?
- Review education and training of engineers and managers to establish a baseline of what each community is comfortable communicating

Communication starts with understanding.

- R. Kline

Has this happened to you?

“What's wrong with this picture?”



Communication Stages

- Receive : Largely a physical (sound) or technical (email) phenomenon
- Attended : Did the recipient pay attention to the message (raise to their consciousness, open the email)?
- Understood : Did the recipient form the desired mental concepts?
- Responded : Did the recipient confirm understanding or was the recipient able to act on the understanding?
- Remembered : Did the recipient commit the facts to memory?

Engineering Training and Education

- Emphasis on models, accuracy, precision, and addressing uncertainty as a statistical quantity
  - Gather data from many projects/cases to integrate into models
  - Apply the data collected to enhance models
  - Learn rules of how to accurately apply models to projects
- Emphasis of engineer training is the concept of “due care” in the generation of products - accepting that sometimes things “just happen”

Management Training and Education

- Most programs heavily involve case studies that illustrate quantitative models in action
  - The cases provide “grounding” as to where the models are valid and how to utilize them
  - Indeed, a tenant from many management students is that models may be easily invalidated by moving to a different set of environmental factors
    - And there are case studies to illustrate this
- The focus on management training is to identify, prevent if possible, and report on things that may disrupt the manager's span of interest

Discourse

- My experience
- Anatomy of a disagreement

Discourse

From my experience...

- Managers want to know if the model truly represents the problems they are about to encounter, or that the model gives them information about how to handle the problems without wasting resources
- Engineers prefer problem-relevant models in which they have experience and desire to use them in the fashion in which they've been trained

Discourse (2)

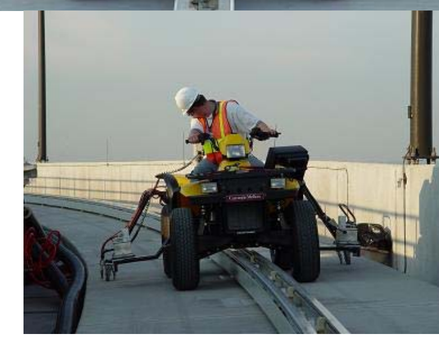
- Conflict arises when the engineer and manager are in disagreement – e.g. “Can we produce a system at the 20% confidence effort estimate?”
- Different views of the data is a possible cause
  - Manager believes that the uncertainty is the management trade space
  - Engineer believes the uncertainty is the inherent variation in performing the tasks
- Both may be correct!! How do we begin a rational discourse?

Example Case Studies

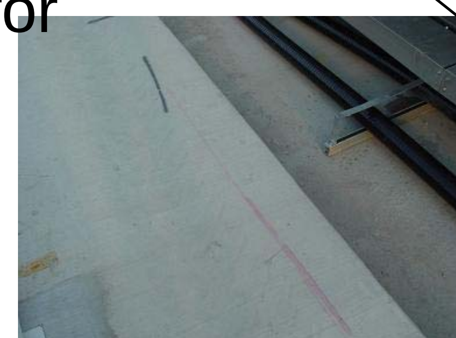
In the following two cases, we will cover two examples of where schedule for production of a robotic system failed to achieve a usable system on time

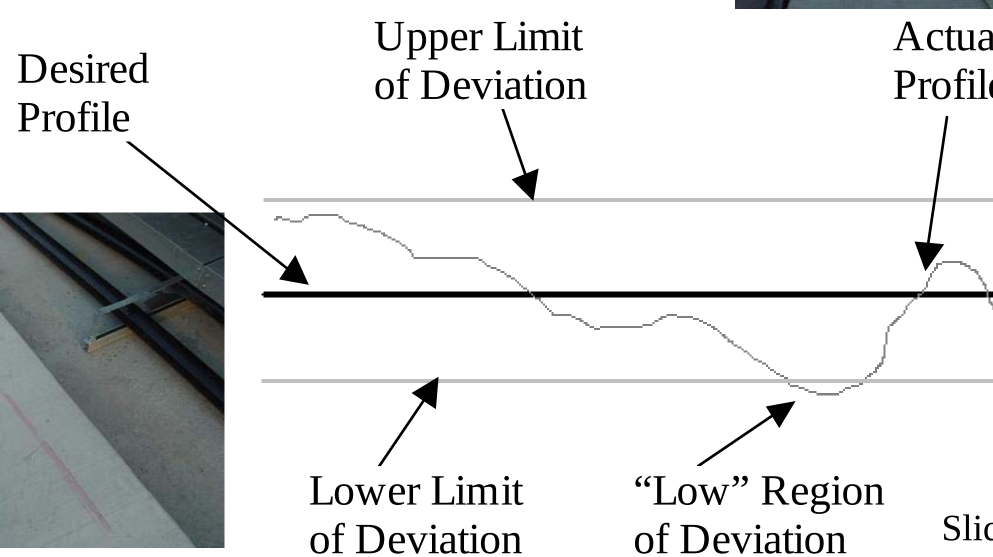
- Surface Assessment Robot – met all stated requirements, unstated requirements cause system to fail to integrate with all stakeholders
- Global Hawk – short engineering / manufacturing design phase led production problems

Surface Assessment Robot



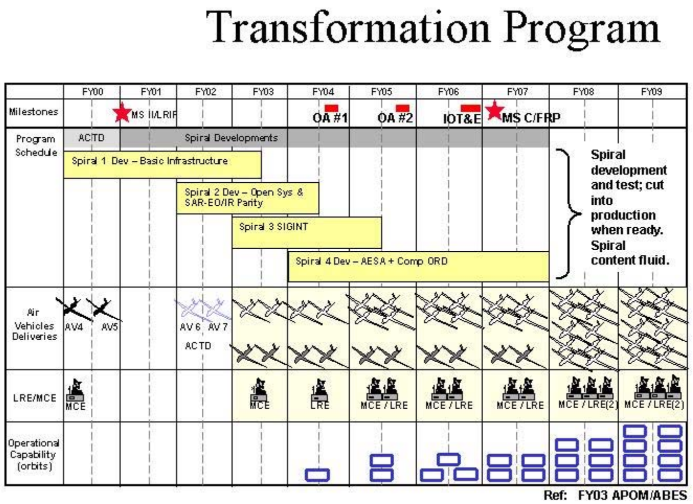
- System detects and marks deviations from the smoothness standard in road surfaces
- Project involved numerous precedented technologies in construction assessment
  - Unprecedented nature of fully taking an engineer out of the loop created requirement development risk
  - Cost/schedule given were sufficient only for a precedented system that could be acquired in a single pass (non-evolution





Global Hawk

- System carries remote sensing payloads under guided flight autonomy command of remote operator



- Engineering analysis for production system was limited due to believe that research prototype was ready for production
- Schedule created on belief that engineering analysis was "close"
- Result: inability to meet full rate production goals

Observations

- Reaction when using cases as the basis to discussion between engineers and managers
- Example outcomes of managers engaging and investing in engineering decisions flowing out from case study dialog
- Strengths and weaknesses

Observations

- Managers who were later exposed to these cases engaged to address the root causes
  - Many proposed additional forward looking models
  - Many engaged on setting estimation parameters in constructive effort models
- Managers began to see where the "trade-space" was outside of the confidence intervals
  - Expressed understanding of the inherent risk in various parameterized descriptions of the environment

Observations

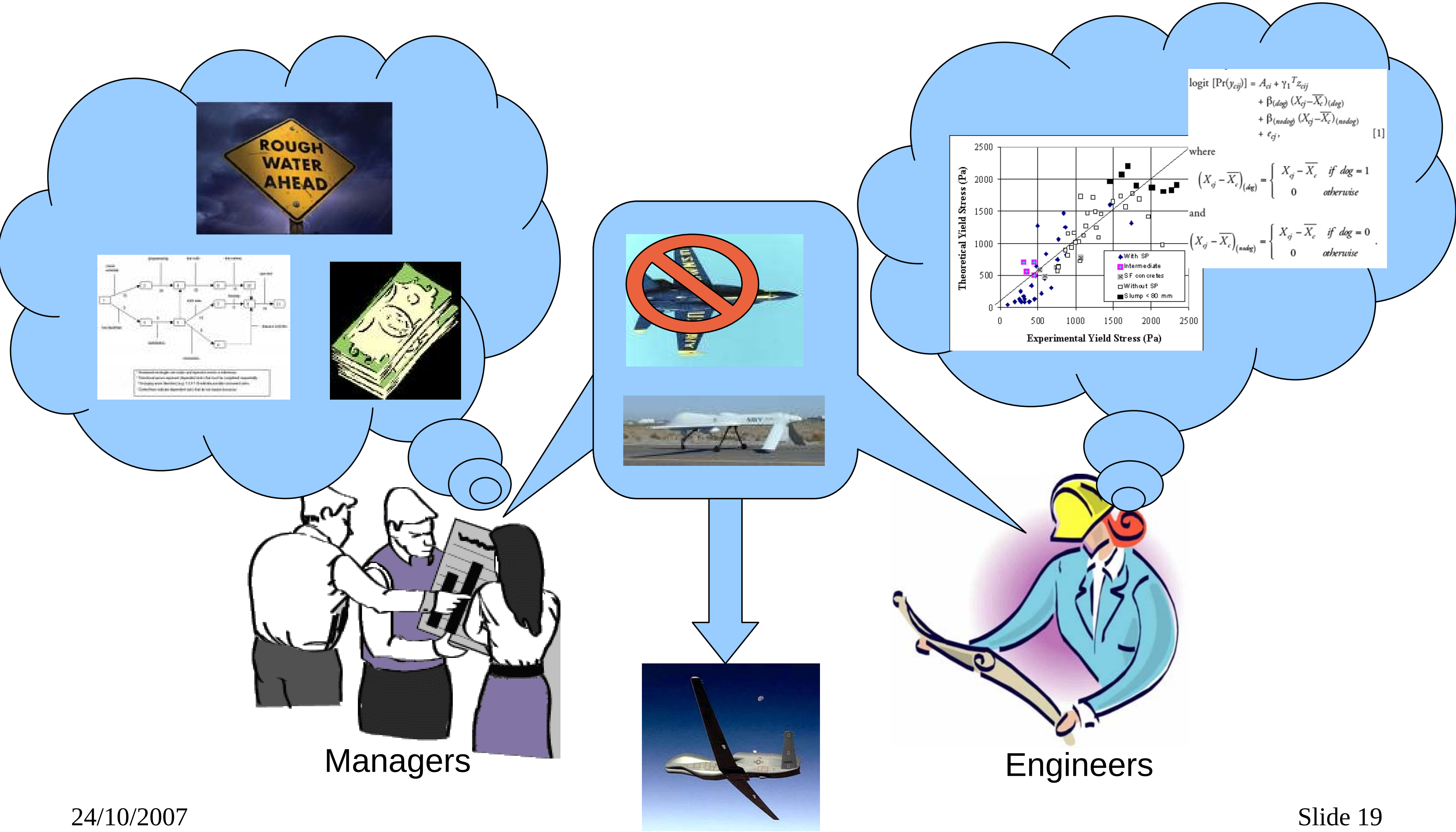
- Using the surface assessment robot case, managers brought up how strategic alignment should be linked to various effort model settings
- Using the Global Hawk UAS case, managers mentioned the importance of having reliable assessment metrics for maturity of engineering *products* in addition to the *processes*
  - Identified the lack of ability to assess reuse
  - Identified the lack of upfront investment to ensure work products could be reused and need to invest to make up for the shortfall

Observations

Case Studies typically do not have “schoolhouse” answers - this is their strength and weakness

- Strength – the case describes the breadth of what happened and the environmental/political factors
- Weakness - the case doesn't tell you what to do if you aren't doing the *exact* same thing in the *exact* same situation and time

Cases as a Common Language



Pitfalls

Two pitfalls I have encountered when using cases to support engineering positions with management

- I want more cases to support your position...
- We have to use the model based result, even if it doesn't make sense!

... and what can be done about these pitfalls

Pitfalls (1)

"That's only one (two, three...) case that supports your model, now give me more cases!"

- Likely that you may only be conversant in a few cases relating to any one set of circumstances
- This may be done if someone is engaging in *selection bias* for which cases they consider for when forming their theory of the solution
- Remember, calibrated models are the integration of many observations, where each observation is a case explained in the parameters of the model!

Pitfall (2)

"The model says something we didn't expect, we have to use the results because its the model"

- "Expect" is based on understanding of this specific project in progress and similar historic cases
- Model may be leveraged beyond its calibration or model parameters do not enable discrimination between cases with different outcomes
- People should examine some relevant case to see how well the model is calibrated to this problem or look for other factors that could impact the result

Review

- Background
  - Communication Facilitation
  - Engineering training and education
  - Manager training and education
- Experiences Using Case Studies in Discourse
- Example Case Studies
  - Surface Assessment Robot
  - Autonomous Helicopter
- Observations & Pitfalls Experienced

Take Away

The goal is effective communication

through engaged listening and speaking.

Motivating cases may be one avenue to

appropriate understanding and responses

in multidisciplinary teams.

Backup Slides

Additional Sources of Case Studies

Defense Acquisition History Project

http://www.army.mil/cmh/acquisition/research/fa_casestudybib.html

AFIT Case Studies web page

http://www.afit.edu/cse/cases.cfm

The Risks Digest

http://catless.ncl.ac.uk/Risks/

Systems Engineering Handbook

Available from INCOSE.org

Technical Project Management Textbooks

one example: Kermer, "Software Project Management: Readings and Cases", McGraw Hill, 1996

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About the Author

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Asset-Based PBL for Navy Warships - A case study for LCS Class Ships

NDIA - 10th Annual Systems Engineering Conference
Oct 24, 2007

Mike Mahon

Topics

- ***Definitions/PBL scaling***
- ***LCS Overview***
- ***Asset-Based PBL Key questions***
- ***Asset-Based PBL challenges/Obstacles***
- ***Asset-Based PBL - keys to success***
- ***Path ahead***

Definitions

What is PBL?

- ***any contract where the primary requirement is to provide products & services based on a pre-determined performance metric.***
- ***The performance metric should in some way be a contributing factor to Operational Availability (Ao).***

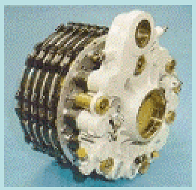
The Navy today boasts of 150+ PBL contracts; most of these are supply-oriented PBLs issued by NAVICP

- ***Most are lower level component based PBLs***

Definitions (cont.)

What is Asset-based?

Component Level



[Tires](#)

System/Eqpt Level

Asset Level

Not all assets are equal in terms of achieving asset-based PBL

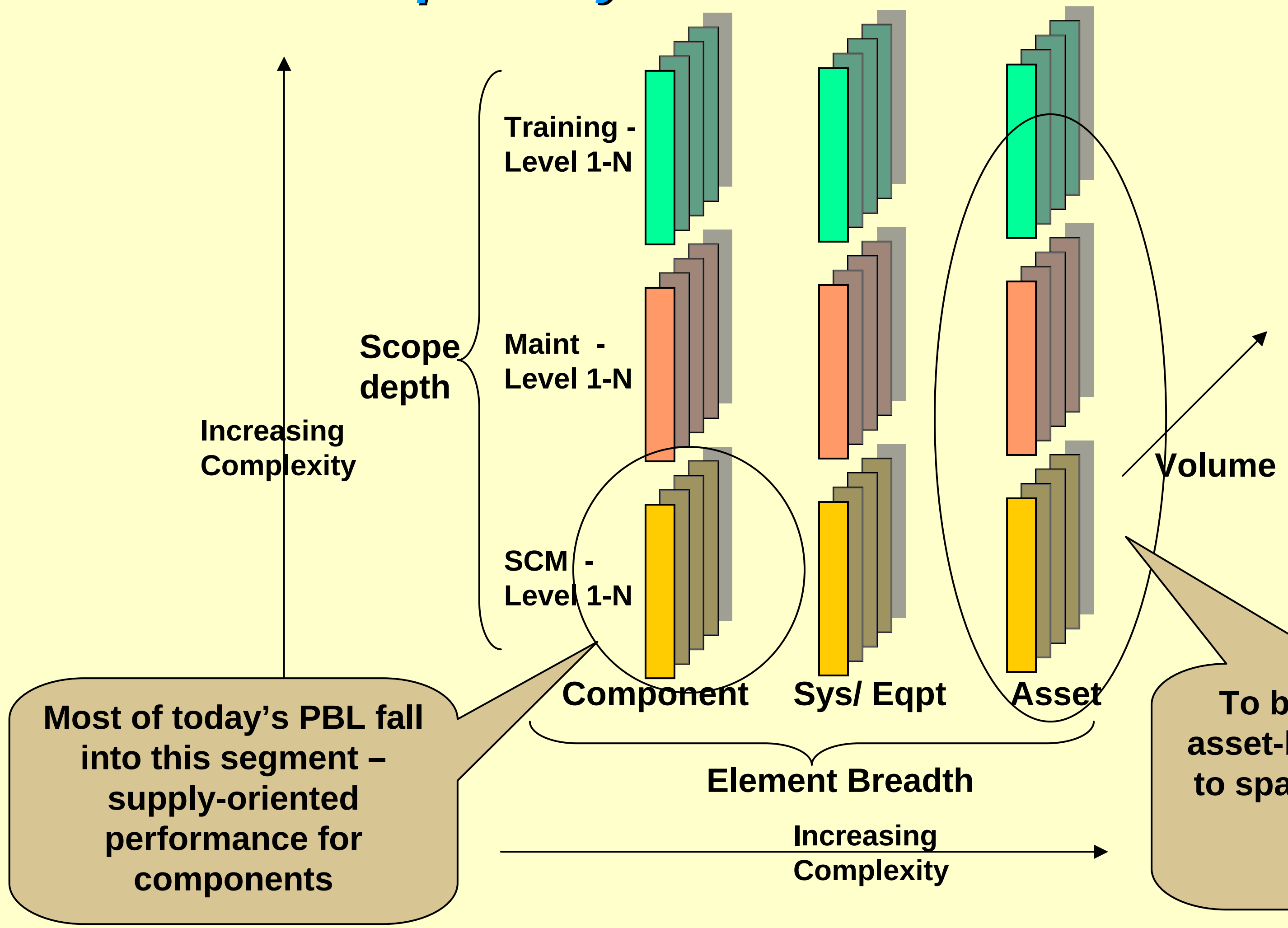
Easier

Complexity is based of number of systems within asset

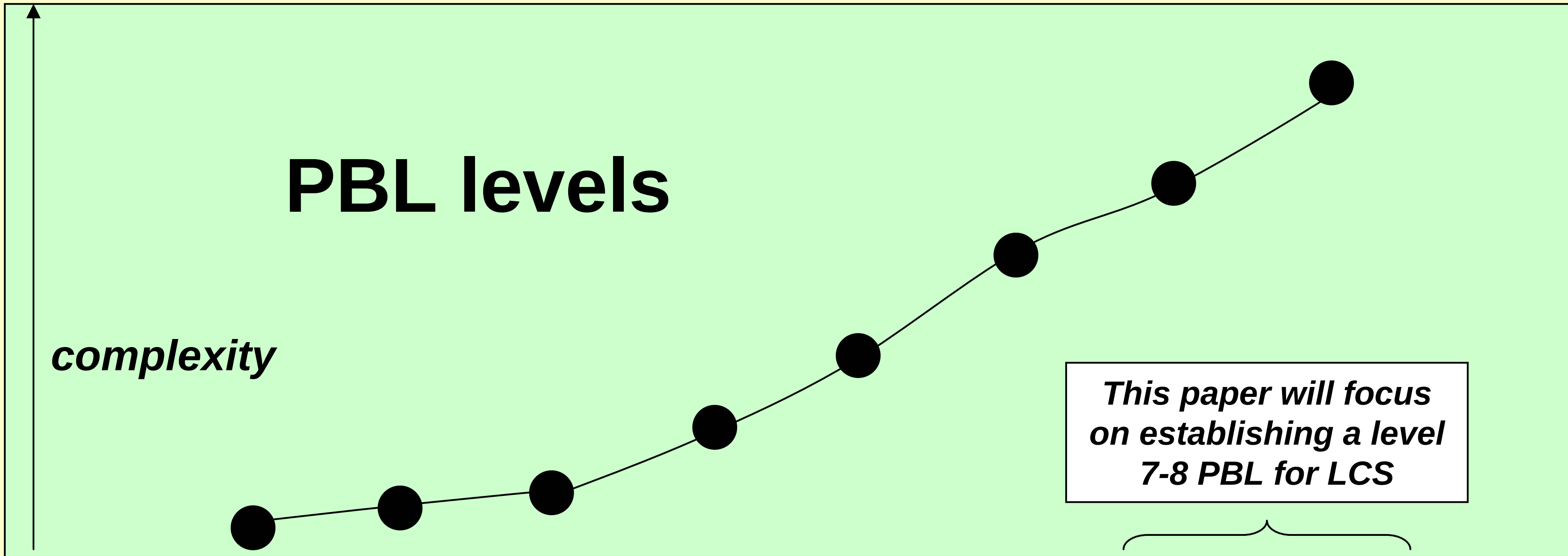
Harder

PBL Complexity

There are two primary dimensions to PBL complexity.



PBL Complexity Scaling



Level	1	2	3	4	5	6	7	8	9
System depth	component	System/ eqpt	component	System/ eqpt	System/ eqpt	Asset-based	Asset-based	Asset-based	Asset based
Domain depth	Supply only	Supply only	Supply only	Supply only	Supply +Maint	Supply only	Supply +Maint	Supply +Maint + Mods	Leased or other special
Element depth	Single element	Single element	Multiple elements	Multiple elements	Multiple elements	Multiple elements	Multiple elements	Multiple elements	

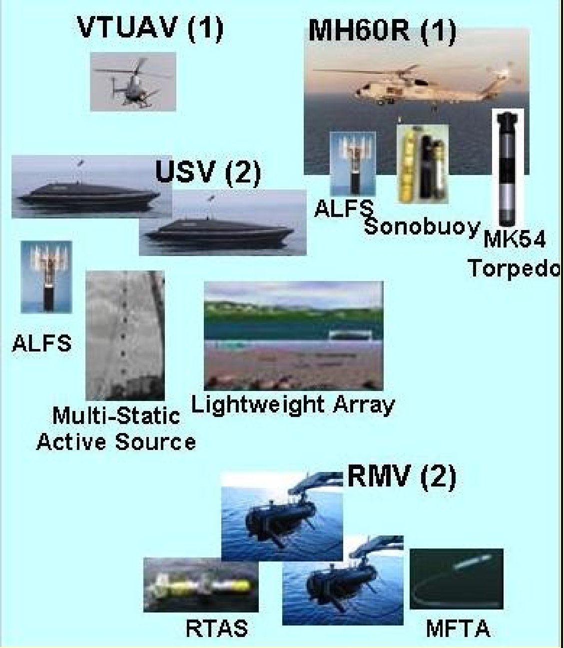
Note: this scale is Mahon developed and not an industry accepted/certified rating system for PBLs

LCS System of Systems

LCS consists of core seaframes designed to host mission packages. Three MP are initially planned.

MIW

ASW



ASUW

LCS Original Requirements

Requirements	THRESHOLD	OBJECTIVE
Sprint Speed (kts)	40	50
Mission Package Payload (mt)	180	210
Range @ Transit Speed (nm)	3500	4300
Navigational Draft (ft)	20	10
Core Crew manning	50	15

Two Years $220M

Any Mission Package / Any Ship / Any Time

- Non-traditional hull forms
- Non-traditional materials
- Non-traditional Propulsion
  - CODAG + Waterjet drive (x4)
- Non-traditional construction practices
- Non-traditional system suppliers
- Modular Open Systems Approach
- Open Computing Architecture
- Automation

LCS Breaks thru many Traditional Paradigms

LCS Flight 0 Acquisition Strategy

6 Industry Concepts
(06 Feb 03)

3 Preliminary Designs
(19 Jul 03)

2 Final Designs
(Contracts Awarded 27 May 04)

FLT 0 Lockheed Martin
(15 Dec 04)

FLT 0 General Dynamics
(14 Oct 05)

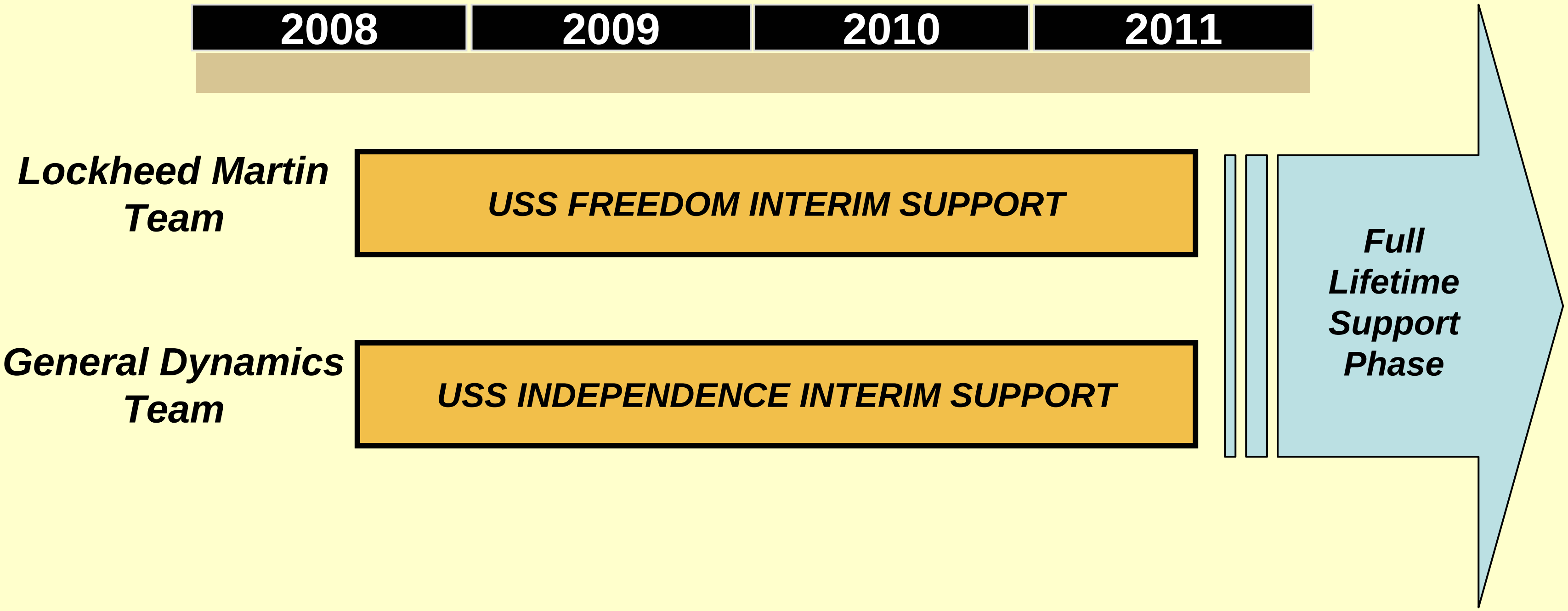
February 2003 — July 2003 — May 2004 — December 2004 — October 2005

First Ships Delivers in Summer 2008

LCS Flight 0 Sustainment Strategy

The US Navy approach for LCS sustainment is to establish the lead shipbuilding teams as lead for sustainment for an interim 36-month period.

- *Concept is to leverage knowledge for design/construction for risk mitigation in initial sustainment phase*



Asset-based PBL – Key Questions

1. ***Will it work? Just because it works at lower levels doesn't mean it's a good thing at a higher level?***
2. ***Will it save money and if so, how much?***
3. ***Can we really put such heavy responsibility for our nations defense in the hands of Industry?***
4. ***What is the fallback if it doesn't work?***
5. ***What will happen to the existing infrastructure that is still required for other ship classes?***

Asset-based PBL – Challenges/Obstacles

1. Jobs/responsibilities – <u>see attached</u>
2. Risk – all dimensions of risk must be identified and mitigation plans established and funded
3. Colors-of-money (RDT&E, SCN, O&M, etc.)
   - it is difficult securing an extra SCN dollar to save two dollars of OM&N
4. Cost/Business case analyses (BCA)
   - Most transformational concepts require a BCA, yet establishing a baseline for today's warships is difficult at best
5. Interaction with other existing PBLs
   - Need to ensure that upper level, asset-based PBLs can work in harmony with existing, established PBLs
6. Patience (or lack of it)
   - Initial performance will be bumpy/full of glitches – all parties need to be prepared for this and work through it.

Asset-based PBL – Keys to Success

1. ***Support from DoD/Customer community***
2. ***A Good approach that manages Risk***
   - ***'stair-step' approach that progresses to full asset-based PBL incrementally***
   - ***Initially costs more to have parallel paths in case of failure***
   - ***Integrated industry-Govt processes***
3. ***Solid team Structure***
   - ***Embraces/uses competition for optimal value***
4. ***Good performance metrics***

Path Ahead

1. ***Build the team and the processes for the three year Interim Sustainment timeframe.***
2. ***Establish initial metric set***
3. ***Do NOT accept PBL from initial suppliers - risk/cost will be too high. Instead use the 3yr period to understand the ship and operational caps and lims – measure everything!***
4. ***Build alternate suppliers – keep competitive environment***
5. ***Establish transition plan for full life-time support***

   (Also build plan to fallback to traditional approach if reqd)

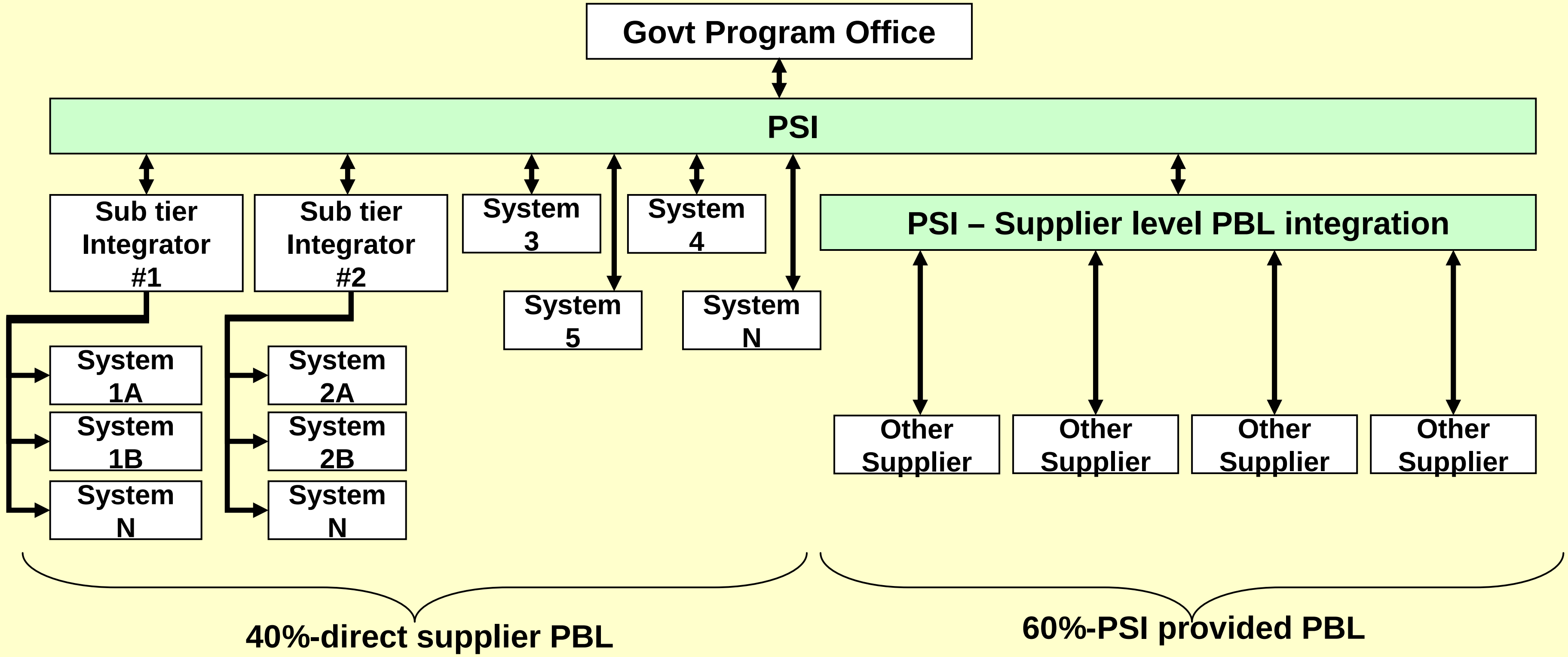
Back-ups

Job/Responsibilities

- ***The biggest obstacle to asset-based PBL (or FSC or CLS) will be from the organic support infrastructure who's very livelihood is threatened by this initiative***
- ***Unlike component based PBL (which never shifted <u>who</u> did the work but <u>how</u> it was contracted), asset-based PBL transitions organic responsibility to industry***
- ***And yet, industry must work with these very same organic activities to develop and operate the Asset-based PBL***
- ***Many people/organizations will be very happy to see asset-based PBL fail and may even work to help it fail.***

Asset-Based PBL - Org structure

- *The business structure of an asset-based PBL for a warship can be very complex.   It consists of many suppliers and varying levels*

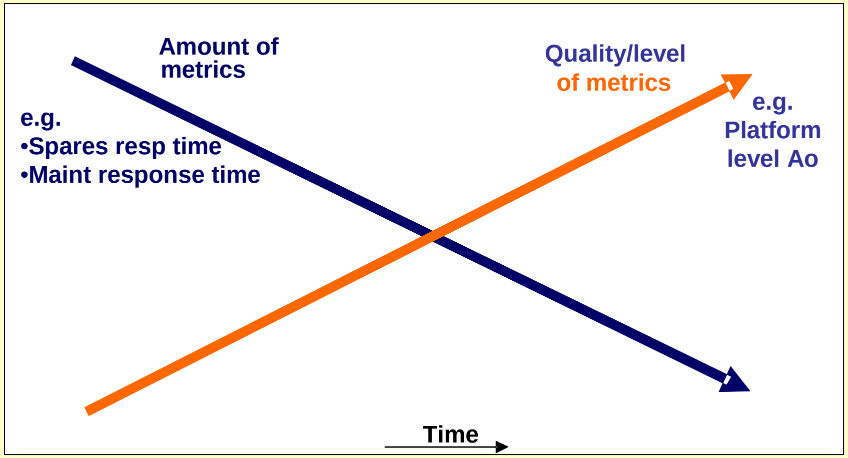


Performance Metrics

- **Measuring performance is critical**
- **Samples metrics include:**

SCM	Maintenance	Training
•Inventory management	•Casualty response time	•Train-to-qualify (T2Q)
•Demand forecasting	•Remote monitoring	•Embedded training
•Transportation	•Condition-based Maint.	•Initial& replenishment crew training
•Requisition processing	•Distance support	•Computer based training & sim
•Parts Repair	•'O' level maint. PM/CM	•Trainer site ops
•Parts replenishment	•'I' level Maint. PM/CM	•Team training
•SCM management	•'D' level Maint	•Training management
	•Maintenance Mgt	

- **To achieve asset-based PBL – in time metric quantity lessens but the metric 'quality' grows**



Integrated Diagnostics (ID) Closed Loop Knowledge System (CLKS)

Steve Head

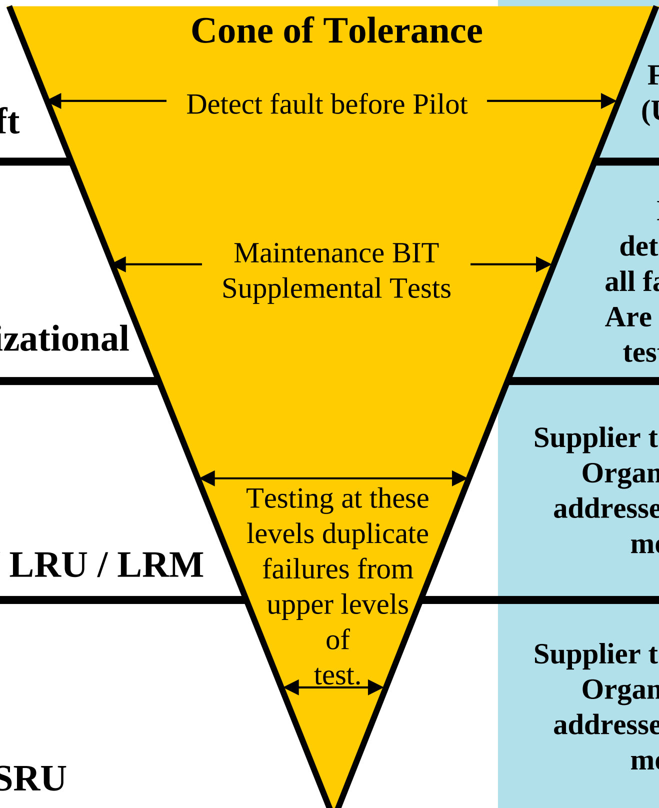
Objective

ID CLKS

- **Develop ability for ID engineer/analyst to gain domain knowledge from integrated data stores**
- **Develop closed loop knowledge system where data is presented and exploited to actively influence**
  - Authoring/monitoring/adjusting of smart diagnostics
  - Engineering/analyst/maintenance technician judgment
- **Maximize use of current transactional databases, domain experience and past successes on aircraft/system programs**
- **Significantly improve sharing and integration of related information across business disciplines to enhance decision making processes**
- **Utilize results and lessons learned from previous Boeing ID data mining studies (2001 and 2002) to better the outcome of ID CLKS**

Traditional Integrated Diagnostics

ID CLKS



Aircraft	**Identify all Failure Modes (Utilize FMEA)**	**BIT information and aircraft environmental conditions are captured by the aircraft.**	**Can the aircraft and/or pilot distinguish between a fault, false alarm, and normal operation?**
Organizational	**Does BIT detect & isolate all failure modes? Are supplemental tests required?**	**Aircraft debrief properly interprets BIT and/or Pilot observable faults.**	**Does the design (Weapon System & Support System) isolate to 1 WRA / LRU / LRM? (BIT, Tech Pubs, SE, etc.)**
WRA / LRU / LRM	**Supplier testing and/or Organic testing addresses all failure modes?**	**Provide WRA / LRU / LRM tester with fault information from the Organizational Level.**	**Does the design (Weapon System & Support System) isolate to 1 SRA / SRU ?**
SRA / SRU	**Supplier testing and/or Organic testing addresses all failure modes?**	**Provide SRA / SRU tester with fault information from the WRA / LRU / LRM tester.**	**Does the design (Weapon System & Support System) isolate to a small number of components ?**

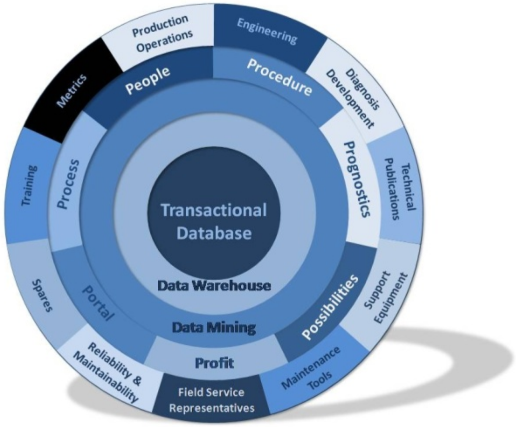
Maturation

Are the Diagnostics Performing as Designed? Test Voids?
Knowledge Engineering starts providing answers!

Why Care About ID Knowledge?

ID CLKS

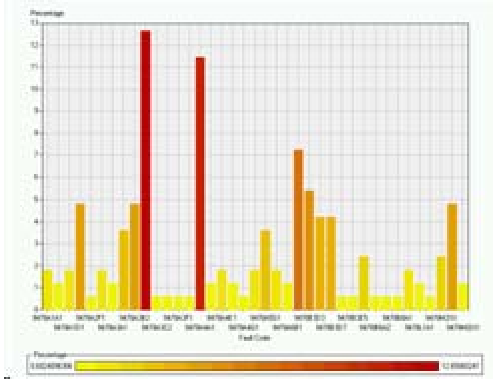
- **Mining data is mining knowledge**
  - Data mining utilizes automated search algorithms (patterns, similarities, correlations or text matching). Data results are visually presented to the user (better understanding and improved judgments).
- **Knowledge has potential**
  - Properly maintained
    - Optimized for use (IT independent)
  - Valued
    - Trying to tell us something - are we listening?
    - Look into the crystal ball - what do you see?
  - Categorized
    - Impact and message
      - Good, missing, dirty or bad data
  - Available at the point of use and to the next specialty
    - Timely and meaningful manner
    - DATA?



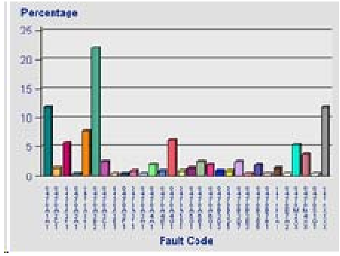
Previous Boeing Knowledge Study Results

ID CLKS

- **Aircraft Program Knowledge Discovery 2001**
  - Discovered correlations between aircraft/system events
  - Identified emerging system issues/trends
  - Identified cause of part/system failure

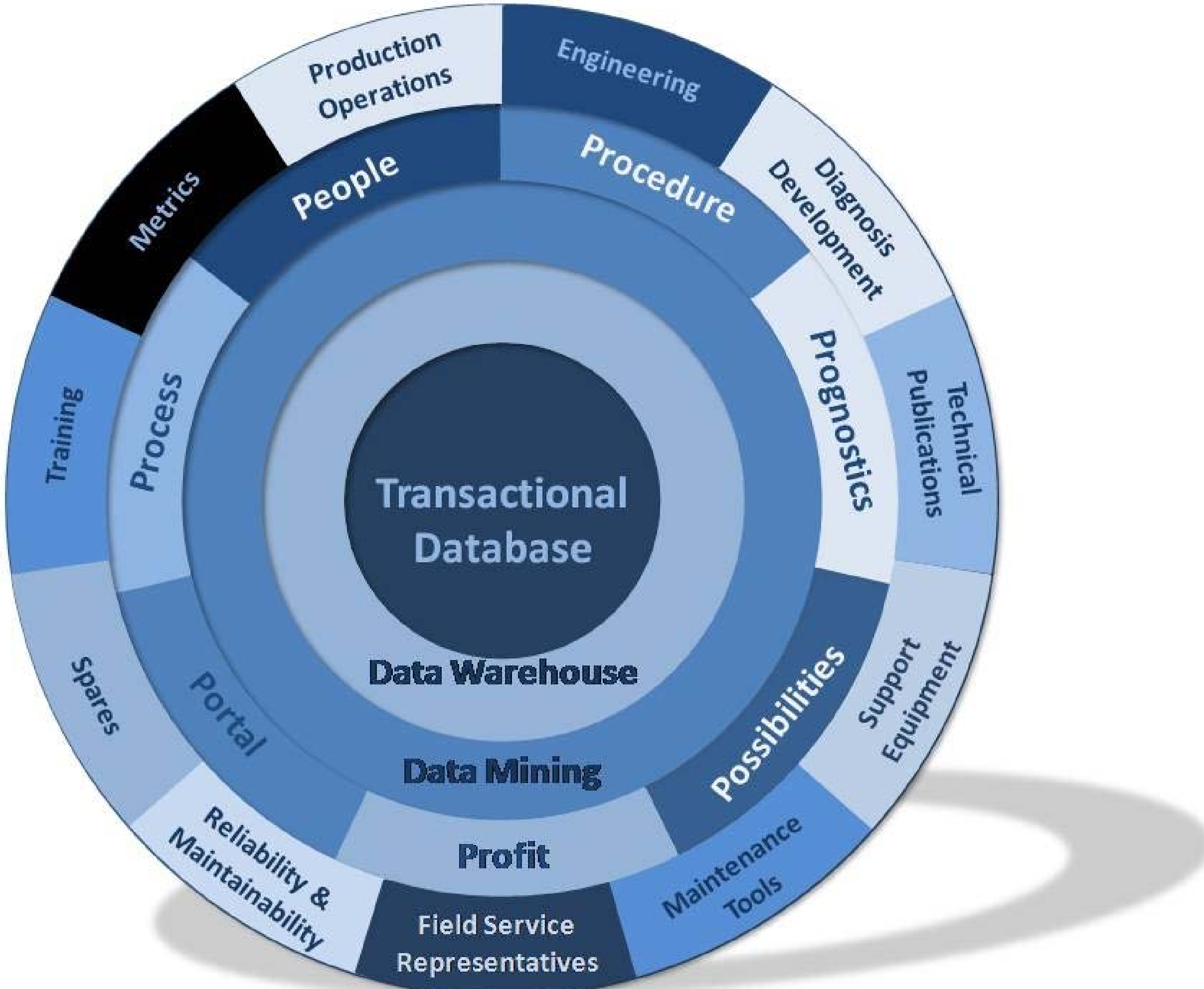


- **Aircraft Program Data Mining Study Results 2002**
  - Identified aircraft with significant failure clustering
  - Identified recurrent faults with specific underlying relationships to aircraft parametric data
  - Identified separate nuisance fault codes for consolidation
  - Identified ideas of improving data quality for wiring faults



Knowledge Wheel

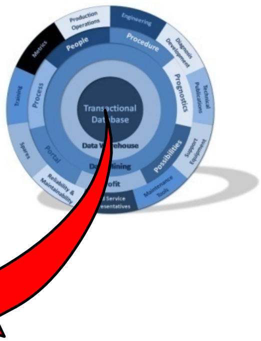
ID CLKS

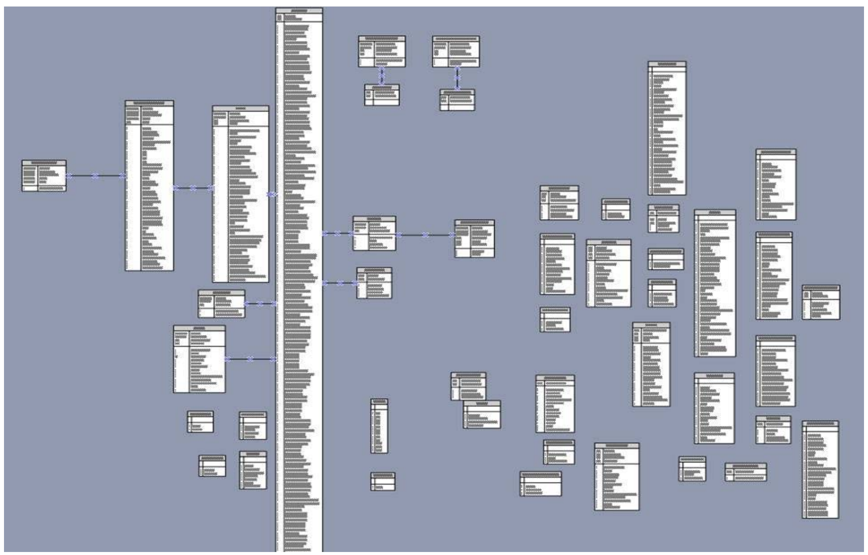


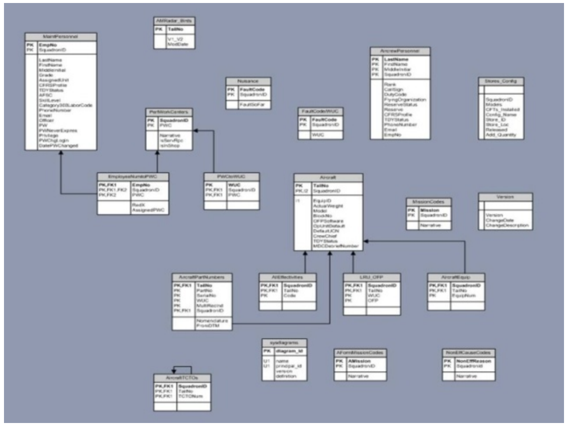
Transactional (Operational) Databases

ID CLKS

- **MANY databases used for day to day business functions**
  - But NOT a data warehouse





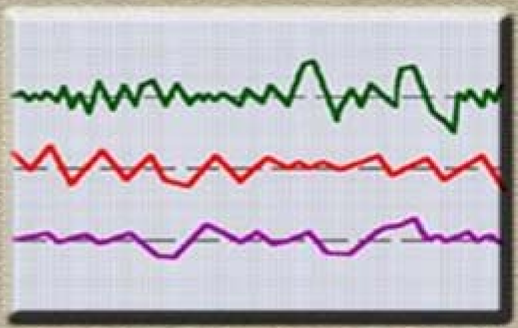


Automated Maintenance Environment

Transactional Sources of Data

ID CLKS

Fault data
- Fault code
- System component performance
- Operational context parameters
- Flight data recording



Maintenance data
- Pilot debrief
- Procedures used
- Actions taken/parts replaced
- Time for action/personnel
- Subsystem/component test results

Logistics data
- Aircraft/part identification and configuration
- Aircraft part usage (sorties, hours)
- LRU/component history
- Spares disposition

- Flight data for single aircraft past flights
- Specific squadrons
- Bases/geographic regions
- Correlation to specific flight text
- Frequency of occurrence

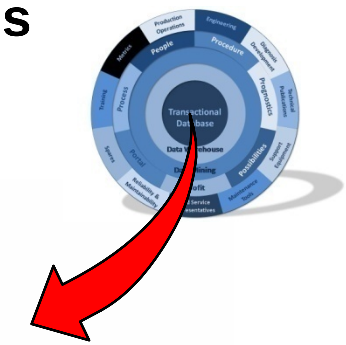
Manufacturing data
- Lot number
- Acceptance test results

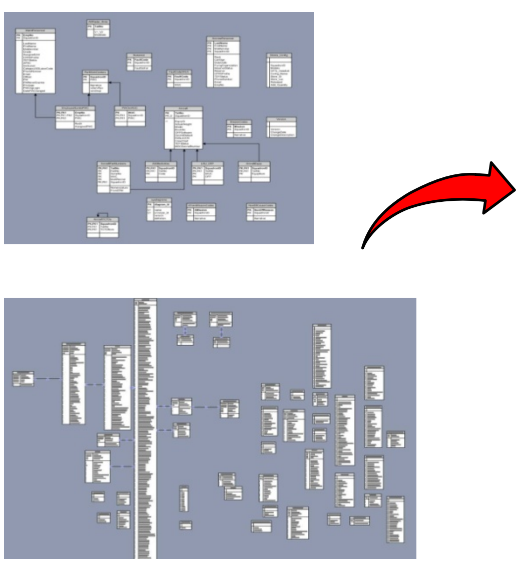
- Aircraft configuration
- Component lot number
- Maintenance actions
- Personnel experience
- I level test results
- Number/pattern of CNDs and RTOKs

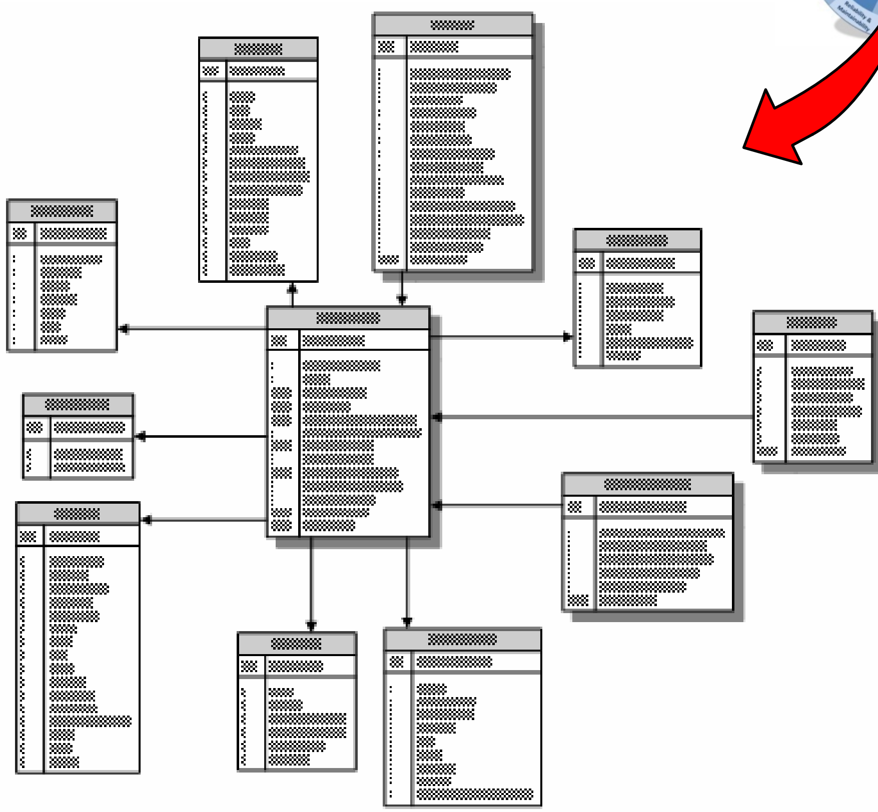
Data Warehouse

ID CLKS

- **Database designed to support data mining process**
  - Extract, Transform and Load (ETL Process)

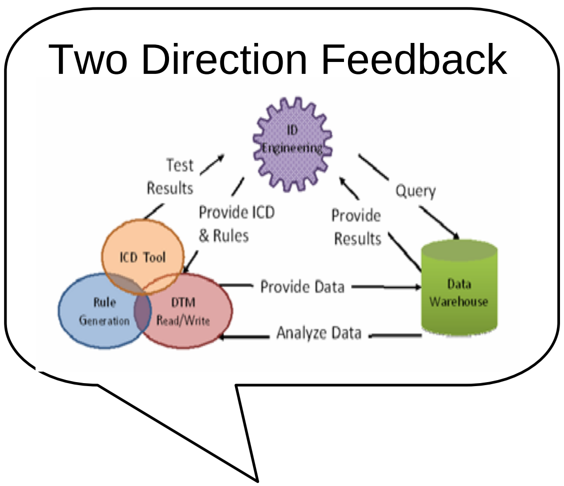


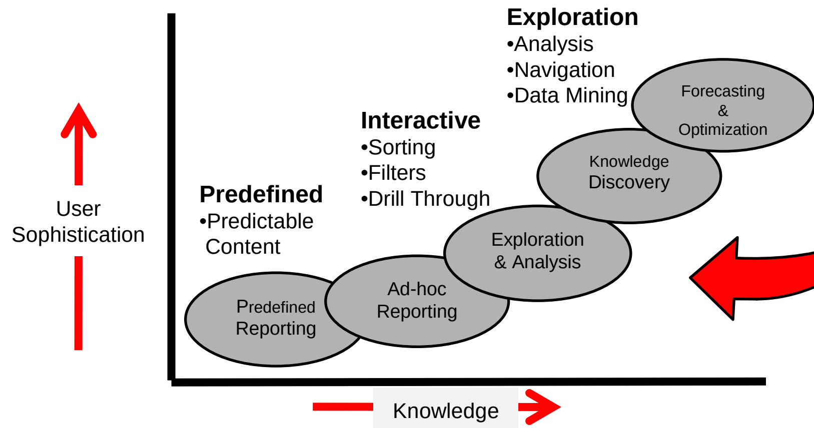


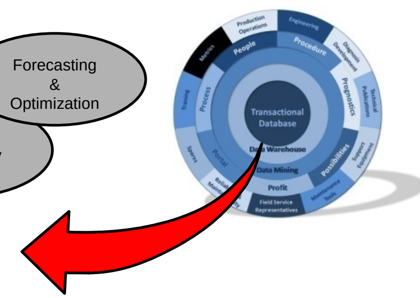


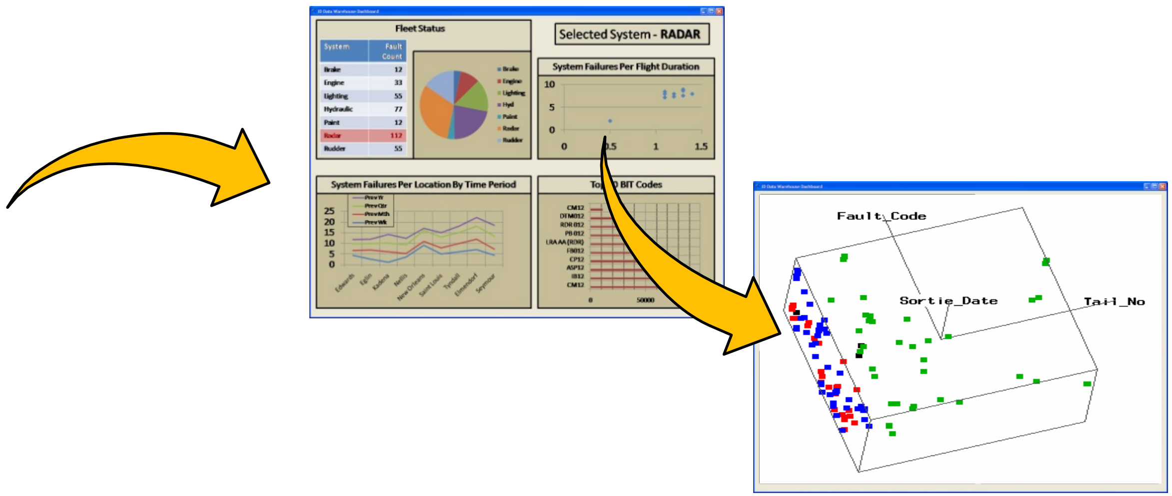
Data Mining and Aircraft Failure Visualization

ID CLKS



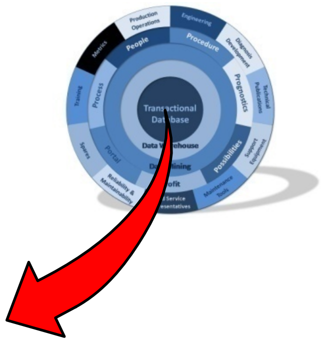






7 P's Visual Knowledge and Results Opportunities

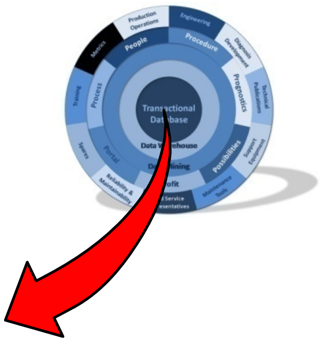
ID CLKS



- **People**
  - Is there a training or staff issue driving the poor diagnostics, Can-Not-Duplicate, Bench-Check-OK, etc?
  - Are required entries within maintenance system filled out completely and correctly?
  - Is there an opportunity to update the maintenance system?
- **Process**
  - Business process improvement? Is process too complicated, not accessible?
  - Could a LEAN approach provide a better solution?
- **Procedure**
  - Does the maintenance procedure need updating or smart diagnostics updated?
  - Is there a false alarm that needs masking?
- **Portal**
  - One web, one login, common user interface?

7 P's Visual Knowledge and Results Opportunities (cont)

ID CLKS

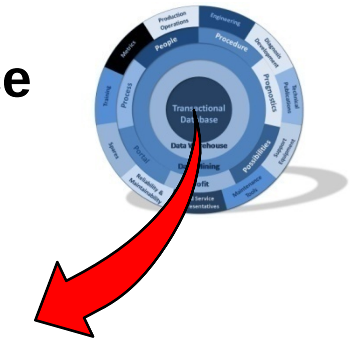


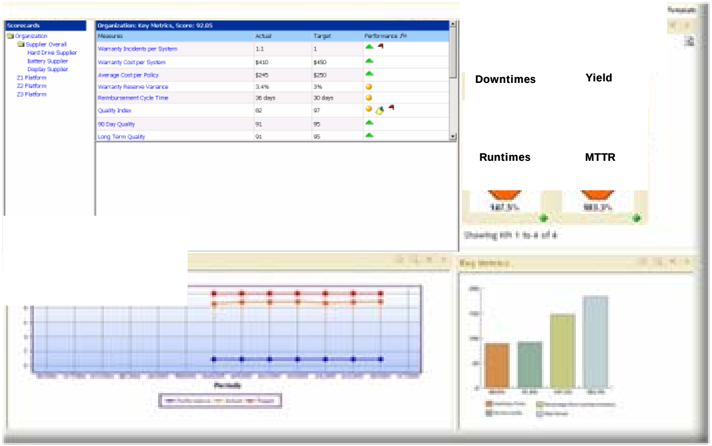
- **Prognostics**
  - If A and B are bad, then C will fail with a certain period?
- **Profit**
  - Is the knowledge discovery or change the exception or the rule?
  - Too costly?
- **Possibilities**
  - What is the data and/or the metrics trying to tell us?
  - Share the knowledge with subject matter experts from applicable business disciplines. Knowledge drives capturing of focused domain knowledge?
  - If a wiring repair maintenance action, compare job closeout WUC with text mined closeout narrative. Flag due to incorrect WUC assignment (LRU instead of wire repair). Unnecessary LRU failures which drives spares?
  - If relationships between flight parameters, generated failures and human observables exist, consider updating diagnostics accordingly?

Knowledge Wheel Disciplines

ID CLKS

- **Knowledge collaboration of related information between business disciplines improves ID influence and maturity including quality and timeliness of applicable decision making processes**
  - Engineering
  - Diagnosis Development
  - Technical Publications
  - Support Equipment
  - Maintenance Tools
  - Field Service Representatives
  - Reliability and Maintainability
  - Spares
  - Training
  - Metrics
  - Production Operations

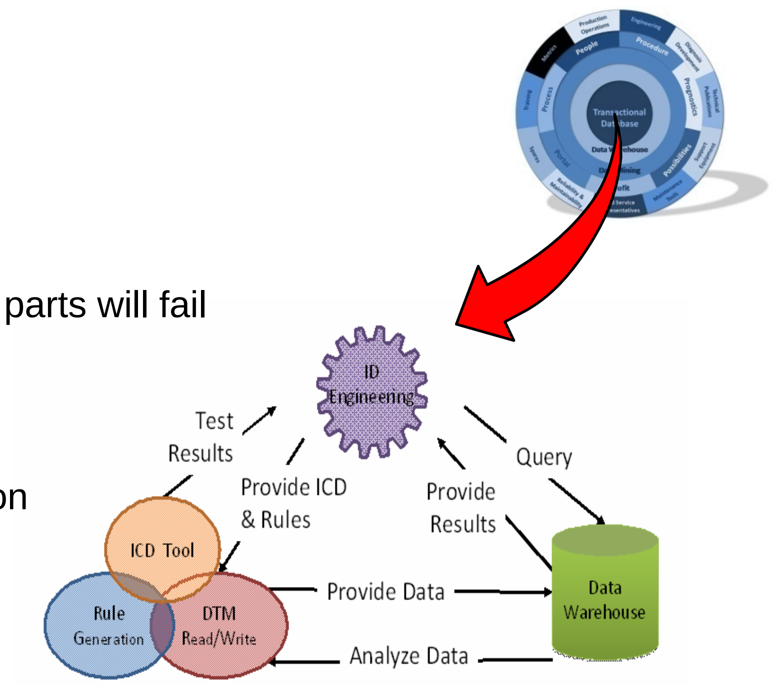




Who benefits?

ID CLKS

- **Boeing**
  - Integrated Diagnostic Engineers
    - Fast & accurate fault rule implementation
  - CFRS/IMIS/AME/SMART TPS
    - Consistent ICD and rule creation
  - Spares & Provisioning
    - Can more accurately predict what and when parts will fail
  - Reliability & maintainability
    - Access to more accurate failure
  - Field Service Reps
    - Fleet reports, trends and proactive information
  - Training
    - Focused Curriculum Updates
- **Customer**
  - Aircraft Pilots
    - More reliable and predictable aircraft
  - Maintainers at Various Levels of Maintenance
    - View of what to expect and complete aircraft history
    - Use of BIT data with Automated Test Sets (Directed TPS)



Summary

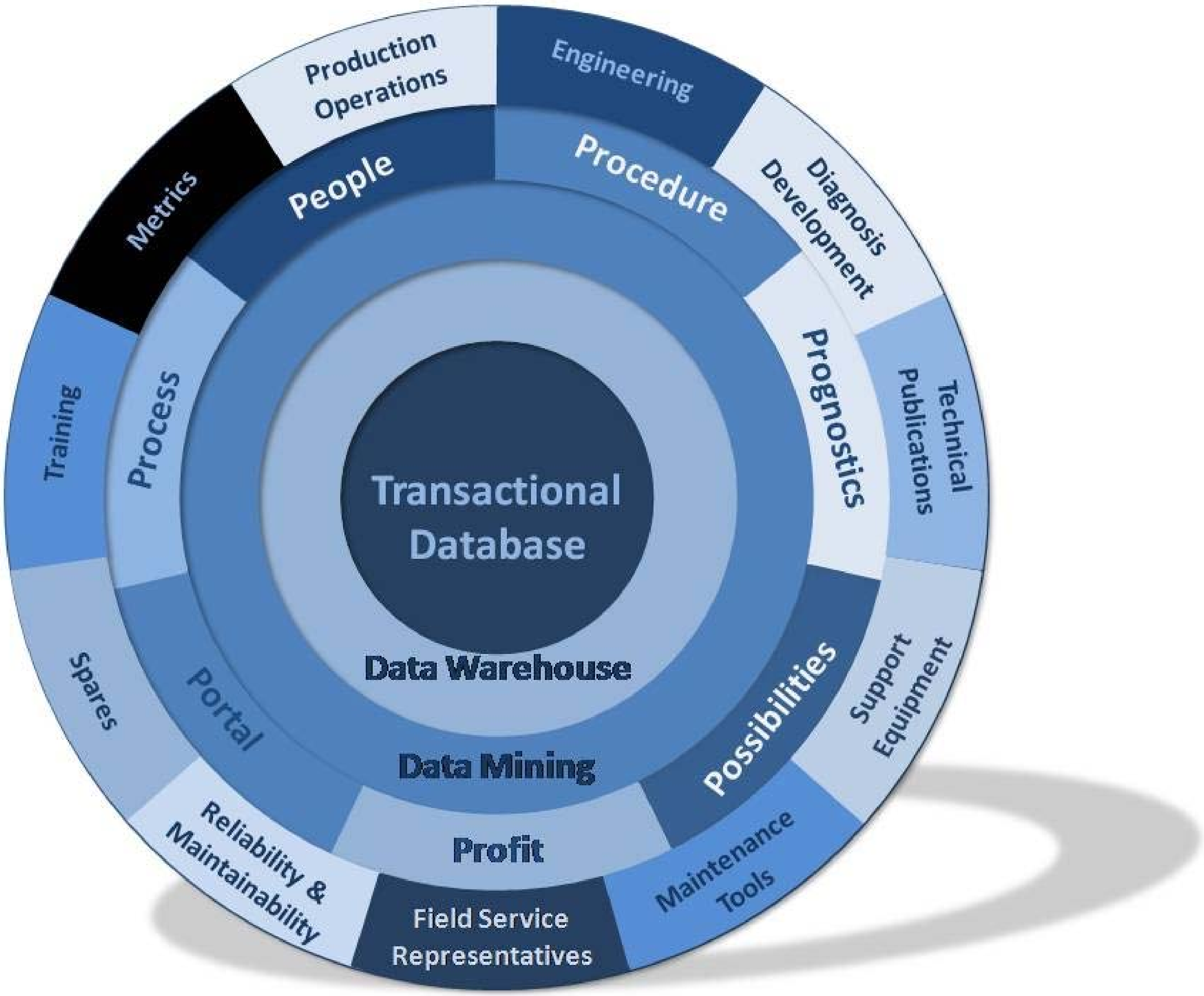
ID CLKS

- **Challenge**
  - Implement an effective method of ID knowledge use and integration across specialties
    - Provide accurate and up-to-date diagnostics
    - Reduce disruptive maintenance problems
    - Reduce cost of maintenance
    - Aid planning for support of future missions

- **Solution**
  - Develop data warehouse and utilize data mining
  - Use predictive modeling to cluster defects and define influences
  - Build on past studies and lessons learned
- **Future Benefits**
  - Enhanced domain knowledge capture, training and transfer
  - Evaluated hidden relationships and cost saving opportunities
  - Increased smart diagnostics maturation and decreased false alarms
  - Knowledge builds upon knowledge

Knowledge is Power - When properly Engineered

ID CLKS



A Strategy for Improved System Assurance

October 24, 2007

Kristen Baldwin
Deputy Director,
Software Engineering and System Assurance
Office of the Under Secretary of Defense
Acquisition, Technology and Logistics

Assurance Efforts Update

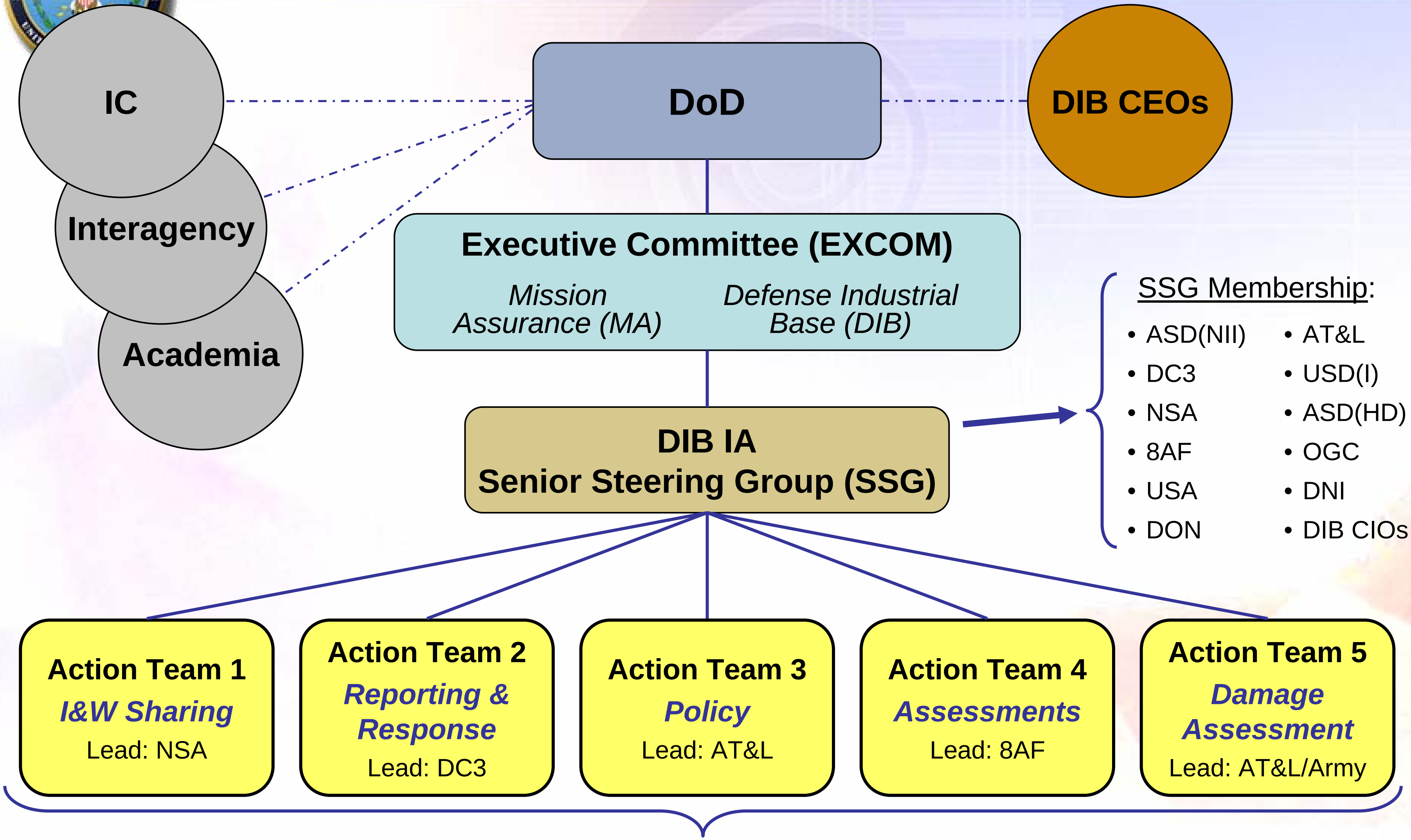
- **Defense Industrial Base Information Assurance Policy Team Efforts**
- **System Assurance Working Group Efforts**
  - Current Tasking
  - 6-bar construct
  - Progress
- **System Assurance Guidebook**
  - Intent
  - Current Status and Way Ahead
- **Program Protection Policy**
- **Software Assurance Initiative**
  - Software Engineering Institute
- **Overall Systems Assurance Progress Report**

System Assurance

- **We continue to be concerned with assurance of our critical DoD assets:**
  - Critical information
  - Critical technologies
  - Critical systems
- **Observations:**
  - Increasing numbers of network attacks (internal and external to DoD)
  - Broader attack space
- **Trends that exacerbate our concerns:**
  - Globalization of our contracts, expanding the number of international participants in our system developments
  - Complex contracting arrangements that further decrease transparency below prime, and visibility into individual components

These trends increase the opportunity for access to our critical assets, and for tampering

DIB IA Tiger Team Structure



Matrixed participation by DoD and DIB representatives in all 5 Action Teams

System Assurance Working Group Update: 6-bar approach

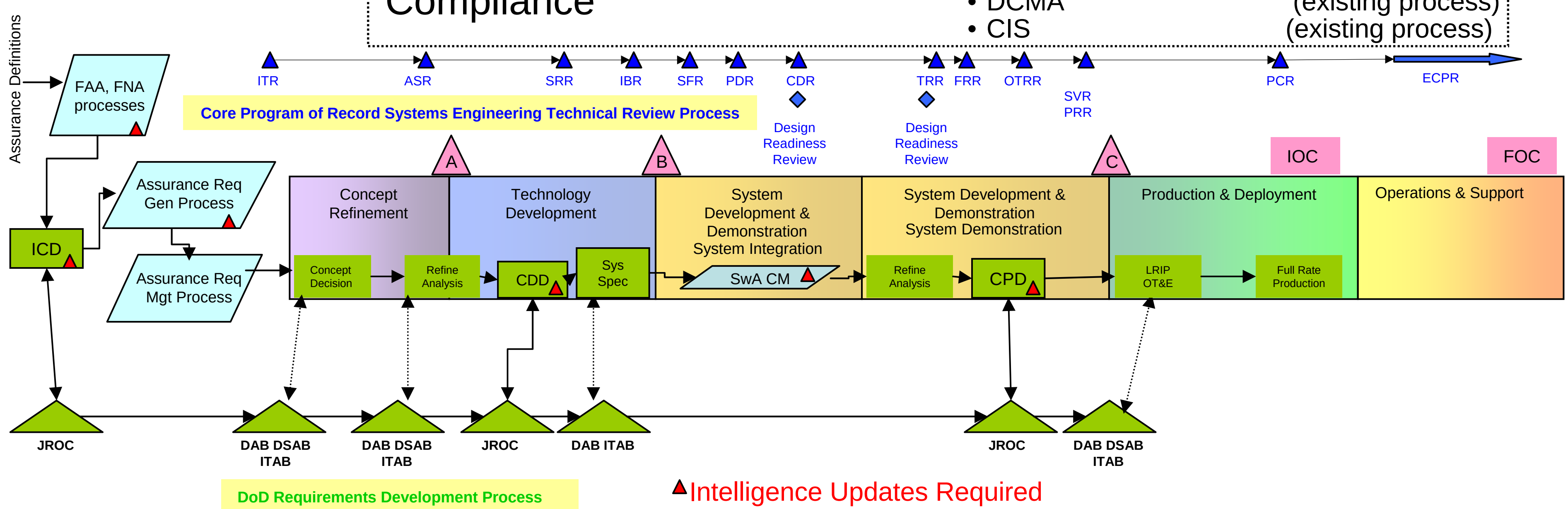
Requirements
Acquisition
Contracting
Development
Oversight
Compliance

- **“Holistic” approach, end-to-end spectrum to capture the most stakeholders**
  - Note: Intelligence Stakeholder is embedded in and across all “bars”
- **Concentrate on six areas of interest, which also happen to be logical grouping of discipline interest and existing policies**
- **Within each “bar”, identify processes, policies to leverage for system assurance**

Systems Assurance Implementation Strategy

JCIDS	• Joint Publications & Definitions	(existing process)
	• ICD, CDD, CPD boiler plate	(existing process)
	• NR KPP Attributes	(existing process)
Acquisition	• "Cost of Doing Business"	(existing process)
	• Guidance for SEP, ISP, TEMP	(existing process)
	• CPI pre-work in FAA and Functional Needs Analysis (FNA)	(existing process)
	• Combine Plans where possible (e.g., OPSEC<>PPP)	(existing process)
	• Threat and risk collaboration	(existing process)
Contracting	• Terms & Conditions	(existing process)
	• Standard Contract Language	(existing process)
	• SDP, PPP	(existing process)
Development	• Technical Requirements	(existing process)
	• Mitigation Guidance (NII, DSS)	(existing process)
	• Software tools (CPI-ID'd, Assess)	(existing process)
Oversight	• SEP and SETR	(existing/new)
	• PM Checklist	(existing process)
	• MDA, Milestone, PSR tools	(existing process)
Compliance	• Acquisition Integrity Office	(existing process)
	• DCMA	(existing process)
	• CIS	(existing process)

Six task blocks shown for breakout purposes only.
Not aligned with timeline, yet



Acquisition Path Forward

- **Create a ‘framework’ to integrate multiple security disciplines and policies**
  - Leverage 5200.39: expand CPI definition to include system assurance and total life cycle
- **Use the Program Protection Plan (PPP) to identify CPI and address assurance for the program**
  - Link plans (e.g., Anti-Tamper, Software Protection, System Engineering, Assurance Case)
- **Modify Acquisition and System Engineering guidance to integrate system assurance across the lifecycle**
  - Milestone Decision Authority visibility
  - Guidebook on Engineering for Assurance for program managers/engineers

Raise the bar:	
Awareness	- Knowledge of the supply chain - Who has access to our critical assets
Protection	- Protect critical assets through security practices - Engineer our systems for assurance

Current Systems Security Policies

Component Protection Sought

Critical Functionality		Critical Information		Critical Technology	
Non-Security	Security	Classified	Un-Classified	Software	Hardware/ Firmware

Defense-In-Depth

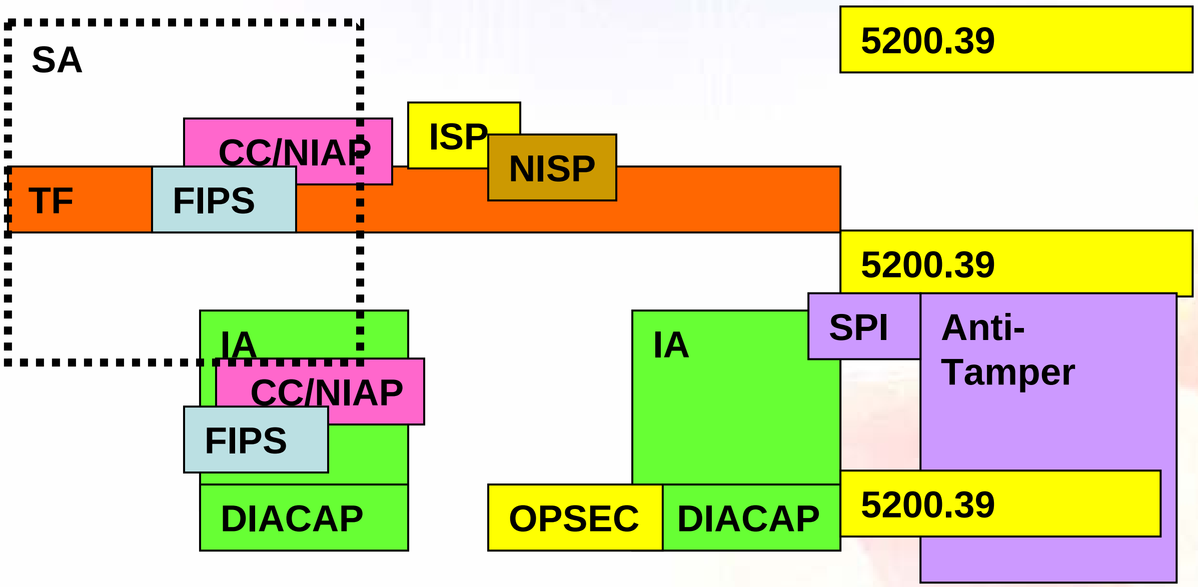
Intelligence

Supply Chain

Engineering

Certification

Documented Plan



Policy Ownership

	DoD - CIO/DSS	DoD – AT&L
DoD – AT&L/S&T	DoD - CIO/DISA	CC/NSA
DoD – NSA	DoD - USD(I)	NIST

Proposed Framework for Security Policies

Component Protection Sought

Critical Functionality		Critical Information		Critical Technology	
Non-Security	Security	Classified	Un-Classified	Software	Hardware/ Firmware

Defense-In-Depth

Intelligence

Supply Chain

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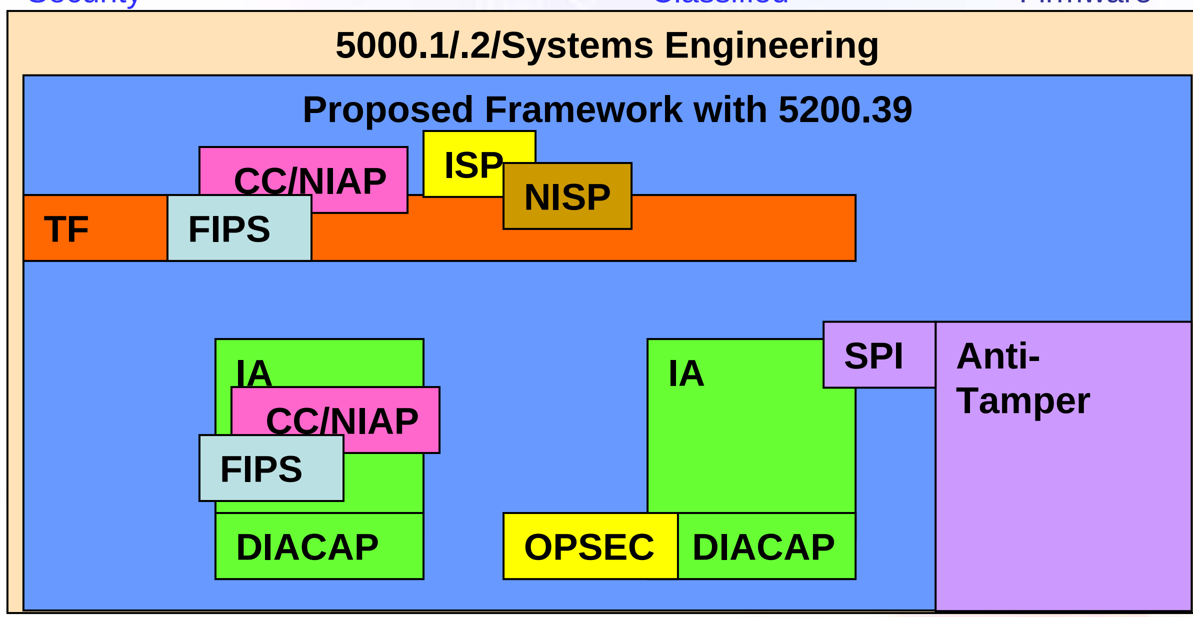


Policy Ownership

	DoD - CIO/DSS	DoD – AT&L
DoD – AT&L/S&T	DoD - CIO/DISA	CC/NSA
DoD – NSA	DoD - USD(I)	NIST

Critical Program Information

New Definition - Draft DoDI 5200.39:

- **E3.6. Critical Program Information (CPI). Elements or components of an RDA program that if compromised, could cause significant degradation in mission effectiveness, shorten the expected combat-effective life of the system, reduce technological overmatch, significantly alter program direction, or enable an adversary to counter, copy, or reverse engineer the technology or capability.**

- **E3.6.1. Technologies become eligible for CPI selection when a DoD Agency or military component invests resources to demonstrate an application for the technology in an operational setting, or in support of a transition agreement with a Program Manager.**
- **E3.6.2. Includes information about applications, capabilities, processes, and end-items.**

- **E3.6.3. Includes elements or components critical to a military system or network mission effectiveness.**

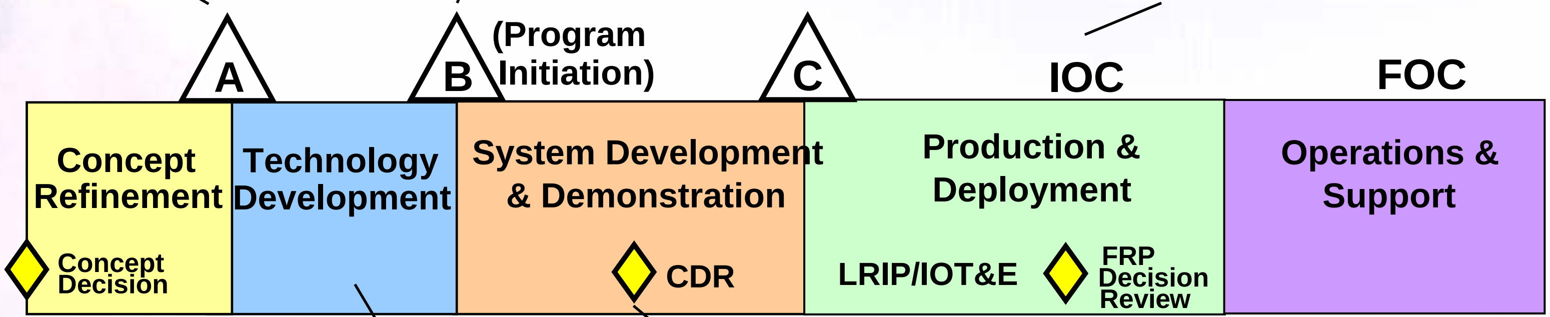
Notional Assurance Implementation

- Identify CPI
- Identify threats
- Develop Plans (SEP, TES)

- Approved SEP, TEMP with details on Assurance
- Milestone Decision approves plans, sets SDD criteria

- Conduct PSRs for Program
- Protection Plans

- Sustainment security plans in place
- Maintenance providers meet security practice
- Upgraded HW/SW configuration managed, validated and verified



- Source selection consideration of supplier FOCI and security practices
- Technology Readiness Assessment
- CPI entered in Horizontal Protection
- Database

- Write Program Protection Plan (PPP)
- Designs meet assurance plans
- Initial verification and validation of critical components

Total Lifecycle Approach to Assured Systems

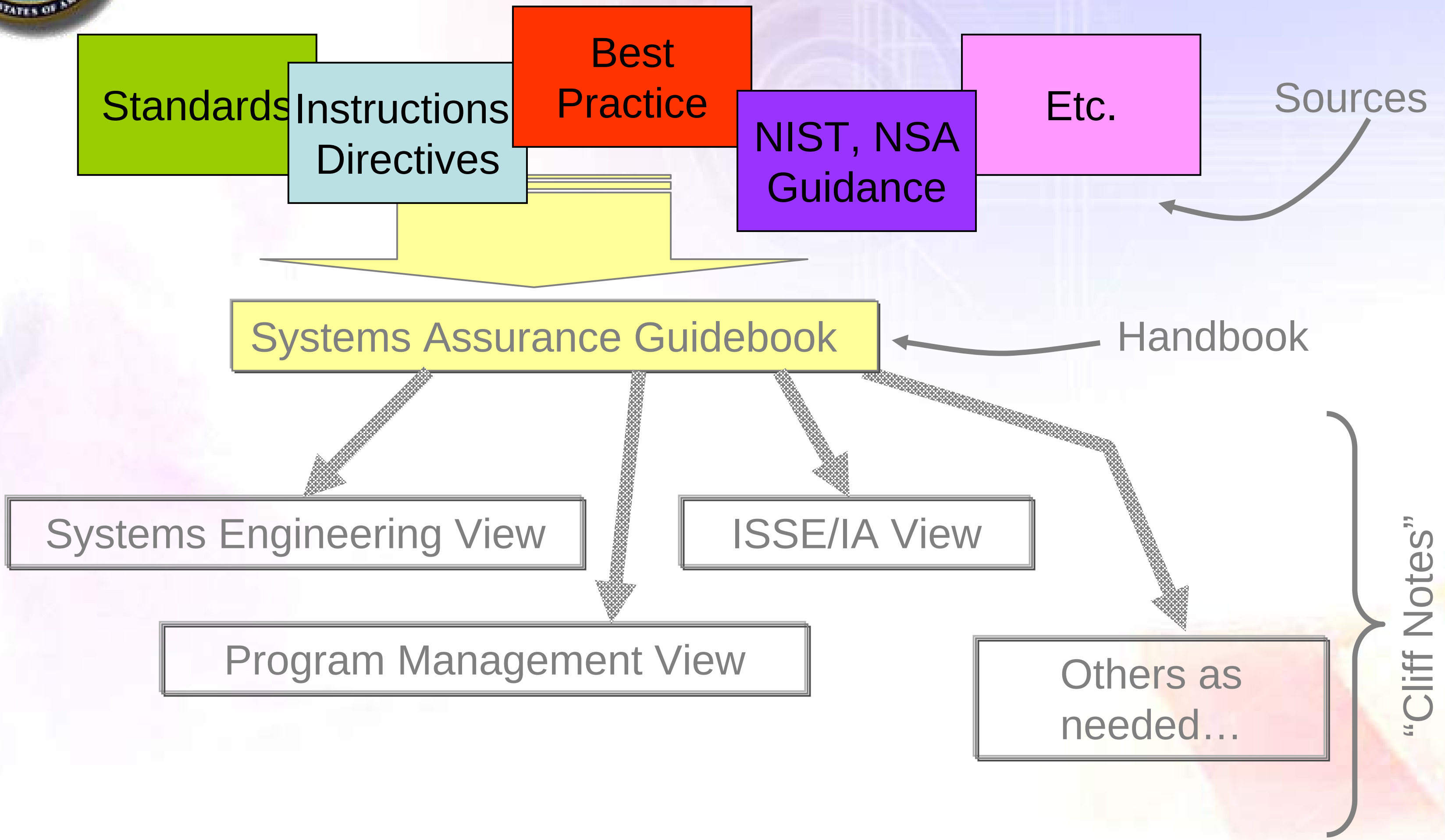
Program Protection Plans

- Policy
  - Revised DoD 5200.39 policy
  - DoD 5000.2 – Deliverable at MS B
- Guidance
    - DAG Chapter 4 and 8, modified to reflect policy changes
    - NDIA System Assurance Guidebook
    - Revised SEP and TEMP Guides
- Support
  - Develop on-site Training
    - Defining CPI consistent with new version of DODI 5200.39
    - Protecting CPI and documenting protection in PPP
  - Senior level support provided to assist programs in defining, implementing, and documenting protection of CPI in PPP

Development Path Forward - SA Guidebook

- **Augments system engineering from documentation through engineering processes and technical reviews**
  - Introduced as early as possible - Where there is the greatest impact
  - Continue through the life cycle
- **Consistent with international standard and current best practices**
  - E.g., Guidebook approach, presentation of process / procedure consistent with ISO/IEC 15288 standard for System Engineering
  - Integrates consideration and leverages numerous existing program protection or security disciplines (e.g., IA, AT, SwA, SPI, PPP)
  - Existing information security / assurance material is summarized, and leveraged by reference, not repeated
    - Enhanced vulnerability detection techniques
    - SwA Body of Knowledge
- **Intent is to provide *practical guidance* on augmenting systems engineering practice for system assurance**
  - Defines “Engineering-in-Depth”!

Guidebook Strategy



Future: Link to Acquisition Guidance, Evolve/Implement into training, education

Guidebook Construct

- **Table Of Contents**

Contact us to participate in stakeholder review

Guidebook Construct con't

- **Table Of Contents**
  - Additional Material
    - Section A: Systems Assurance Concept and Methodology
    - Section B: Correspondence with Existing Documentation, Standards efforts, etc.
    - Section C: Contacts in Communities of Interest and Practice
    - Section D: Anti-Tamper
    - Section E: Enterprise Processes
    - Section F: Technical Guidance Research & Development (R&D)
    - Index

Contact us to participate in stakeholder review

Guidebook Status

- **Stakeholder review – Comments due 31 Oct 07**
  - Request copy for comment ATL-SSA@osd.mil
- **Comment adjudication and release by 31 Dec 07**
  - Version 0.9 of the Guidebook, to be updated over time
- **Pilots**
  - Systems Assurance innovators and areas where comprehensive expertise in one or more relevant domains exists
  - Starting Summer, 2007
- **Write specific stakeholder views**
  - Focus: Derived from the Guidebook, “get the right content” (by audience)

Contact us to participate in stakeholder review

System Assurance Overall Progress Report

System Assurance Progress Report
--a sampling of activities

Requirements - JCIDS

- Modify Joint Publications & Definitions to include SA
- Modify ICD, CDD, CPD boiler plate to incorporate SA
- CPI pre-work in FAA and Functional Needs Analysis (FNA)
- Modify NR KPP Attributes to address SA
- Develop text to discuss Systems Assurance within JCIDS documents

☒ Sample boiler plate presented at SAWG meeting – 7 June 2007

Acquisition – Program Protection Planning (PPP) Process

- Define process required to identify CPI components

☒ Submitted edits to DODI 5200.39 with definition of CPI to incorporate SA interests – May 2007

☒ Drafted formal PPP review process slide set – 18 May 2007

☒ Conducted review of Component PPP processes, tools – 1 Aug 2007

☒ Developed and submitted PPP process resource estimate – 30 Aug 07

☐ Draft common PPP development process – due October 2007

System Assurance Progress Report

Development - Guidance for SEP, ISP, TEMP

- ☒ Updated Systems Engineering Plan (SEP) Guide to include system assurance – Aug 2007
- ☒ Modified Defense Acquisition Guide (DAG) Chapter 4 on systems engineering
- ☐ Modifying DAG Chapter 8

Development - Guidebook

- ☒ NDIA Guidebook released to stakeholders – 19 Sep 2007
- ☐ Adjudicate comments and release Version 0.9 – 31 Dec 2007

Oversight - SA Content for Program Support Reviews

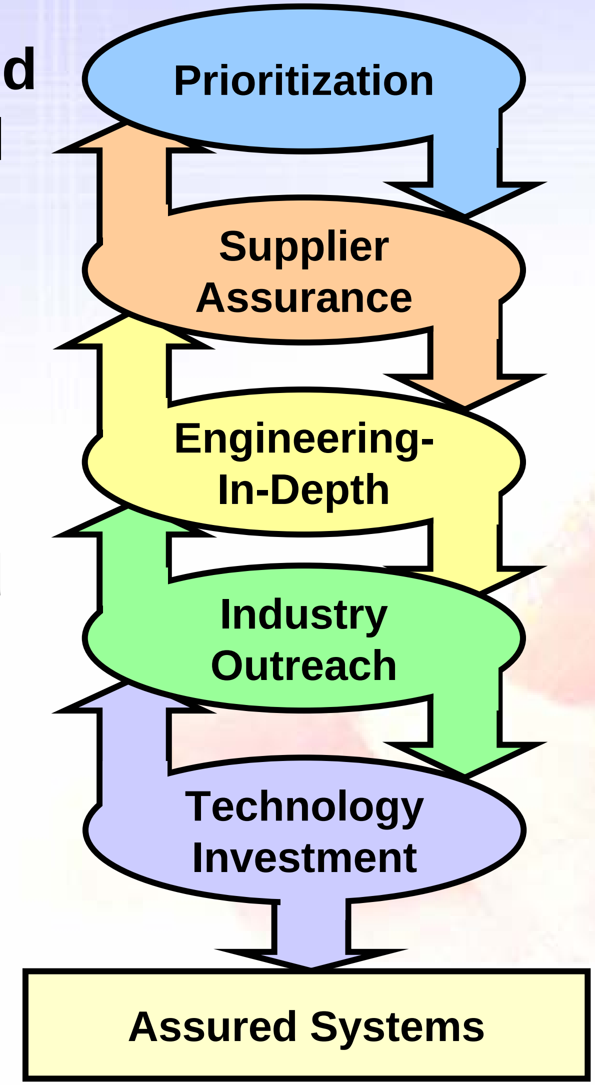
- – Define how programs should be assessed for compliance with systems assurance policy and guidance
- ☒ Developed guidance and questions – May 2007
- ☒ Conducted pilot assessment – June 2007

Intelligence Community collaboration

- ☒ Developed and submitted estimate of impact on CI resources to conduct threat assessments– May 2007

System Assurance: *What does success look like?*

- The requirement for assurance is allocated among the right systems and their critical components
- DoD understands its supply chain risks
- DoD systems are designed and sustained at a known level of assurance
- Commercial sector shares ownership and builds assured products
- Technology investment transforms the ability to detect and mitigate system vulnerabilities



Questions/Comments

DoD Security Policies

- **The DoD Acquisition System must develop secure weapon systems and must increase the security of the acquisition process itself.**
- **The purpose of secure warfighting systems and acquisition processes is to protect the DoD technology lead, develop warfighting systems that cannot be usurped or disabled, and ensure the secure flow of information during war and peacetime for its warfighting systems and corporate infrastructure.**
- **Primary policy concerned with securing the warfighting acquisition process and systems:**
    - DODI 5200.39 Security, Intelligence, and Counterintelligence Support to Acquisition Program Protection

DoD Security Policies

- **Countermeasures – methods for protecting CPI**
  - System Assurance (DAG Chapter 4 & 8, MIL-HDBK-1985 Secure System Design)
  - Classification (DODD 5200.1 Information Security Program, ISP)
  - Network security (DOD8500.01E Information Assurance)
  - Secure communications (C-5200.5 Communications Security)
  - Hardcopy document markings
  - Physical security (DODI 5200.08 Security of DoD Installations and Resources)
  - Operational security (DODD 5205.02 OPSEC)

Backup Slides

Top Software Issues*

1. The impact of requirements upon software is not consistently quantified and managed in development or sustainment.
2. Fundamental system engineering decisions are made without full participation of software engineering.
3. Software life-cycle planning and management by acquirers and suppliers is ineffective.
4. The quantity and quality of software engineering expertise is insufficient to meet the demands of government and the defense industry.
5. Traditional software verification techniques are costly and ineffective for dealing with the scale and complexity of modern systems.
6. There is a failure to assure correct, predictable, safe, secure execution of complex software in distributed environments.
7. Inadequate attention is given to total lifecycle issues for COTS/NDI impacts on lifecycle cost and risk.

*NDIA Top Software Issues Workshop August 2006

Fragmented Systems Security Policies

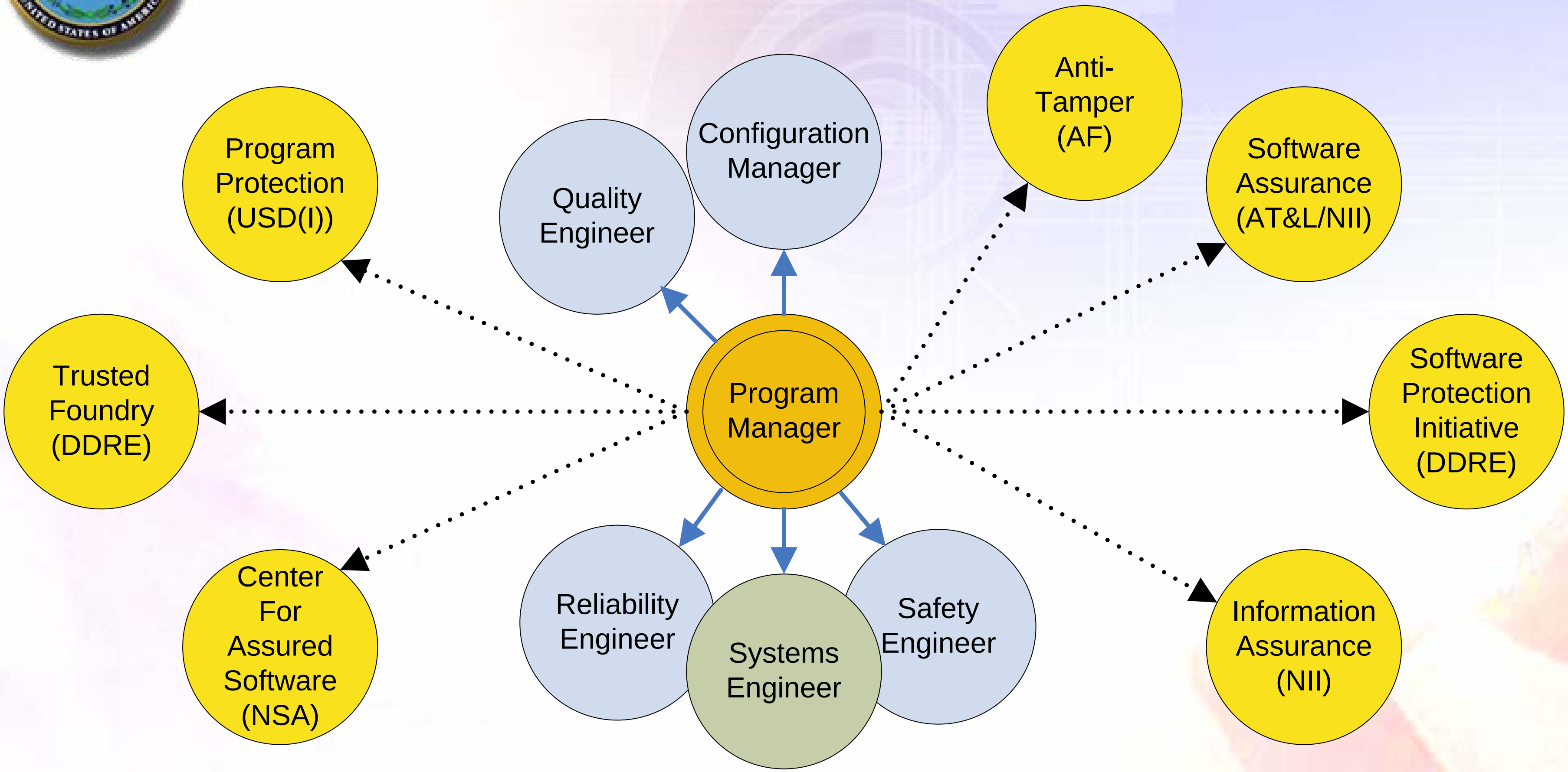
Each policy:

- **Affects different parts of the life cycle**
  - R&D, acquisition, foreign ownership
- **Applies to a different subset of DoD systems**
  - NSS, IT, MDA, ACAT 1C, etc.
- **Assures different 'type' of components**
  - information, leading technology, functionality
- **Mandates a different set of defense tactics**
  - intelligence, engineering, documented plan, certification & accreditation

- **CC – Common Criteria**
- **DIACAP – DoD Certification & Accreditation**
- **FIPS – Federal Information Processing Standards**
- **ITAR – International Traffic in Arms Regulation**
- **IA – Information Assurance**
- **ISP – Information Security Program**
- **NIAP - National Information Assurance Partnership**
- **NISP – National Industrial Security Program**
- **OPSEC – Operational Security**
- **5200.39 – DODD 5200.39 Security, Intelligence, and Counterintelligence Support to Acquisition Program Protection**
- **SA – System Assurance**
- **SPI – Software Protection Initiative**
- **TF - Trusted Foundry**

Current approach does not have systems-of-systems perspective

System Assurance Context for the PM



<u>System Assurance – Working Definition</u>

Level of confidence that a system functions as intended, is free of exploitable vulnerabilities, and protects critical program information

Consequences of Fragmented Systems Assurance Initiatives

- Lack of Coherent Direction for PMs, and others acquiring systems
  - Numerous, uncoordinated initiatives
  - Multiple constraints for PMs, sometimes conflicting
  - Loss of time and money and lack of focus on applying the most appropriate engineering for systems assurance for each system
- Synergy of Policy – Multiple ownership
  - Failure to capitalize on common methods, instruction among initiatives
- DoD Risk Exposure
  - Lack of total life cycle view
  - Lack of a focal point to endorse system assurance, resolve issues, advocate PM attention
  - Lack of system-of-systems, architecture perspective on system assurance
  - Potential for gaps in systems assurance protection

Safety of Unmanned Systems

Sponsored by

Defense Safety Oversight Council Acquisition and Technology Programs Task Force (DSOC ATP TF)

Status Update

Michael H. Demmick
24 October 2007

Agenda

- Leadership
- Background
- Objectives
- Approach
- Progress
- Organization
- Workgroup participants
- Precepts Review
- Final Product
- Summary

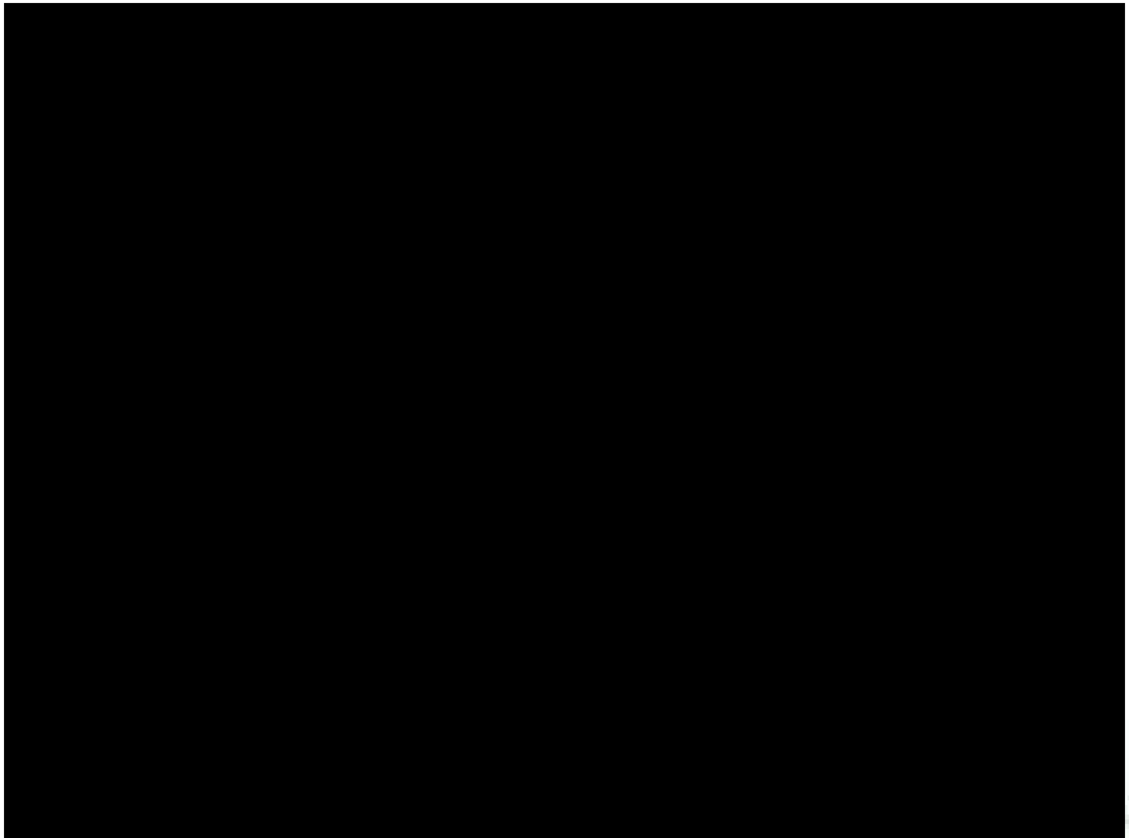
Unmanned Systems Leadership

- **OSD Sponsor**
  - **Mr. Mark Schaeffer, Director, Systems and Software Engineering & Chairman, DSOC ATP TF**
  - **Dr. Liz Rodriquez-Johnson, Executive Secretary, DSOC ATP TF**

Why Safety of UMSs?

MQ-1 PREDATOR WITH HELLFIRES (USAF)

[redacted]

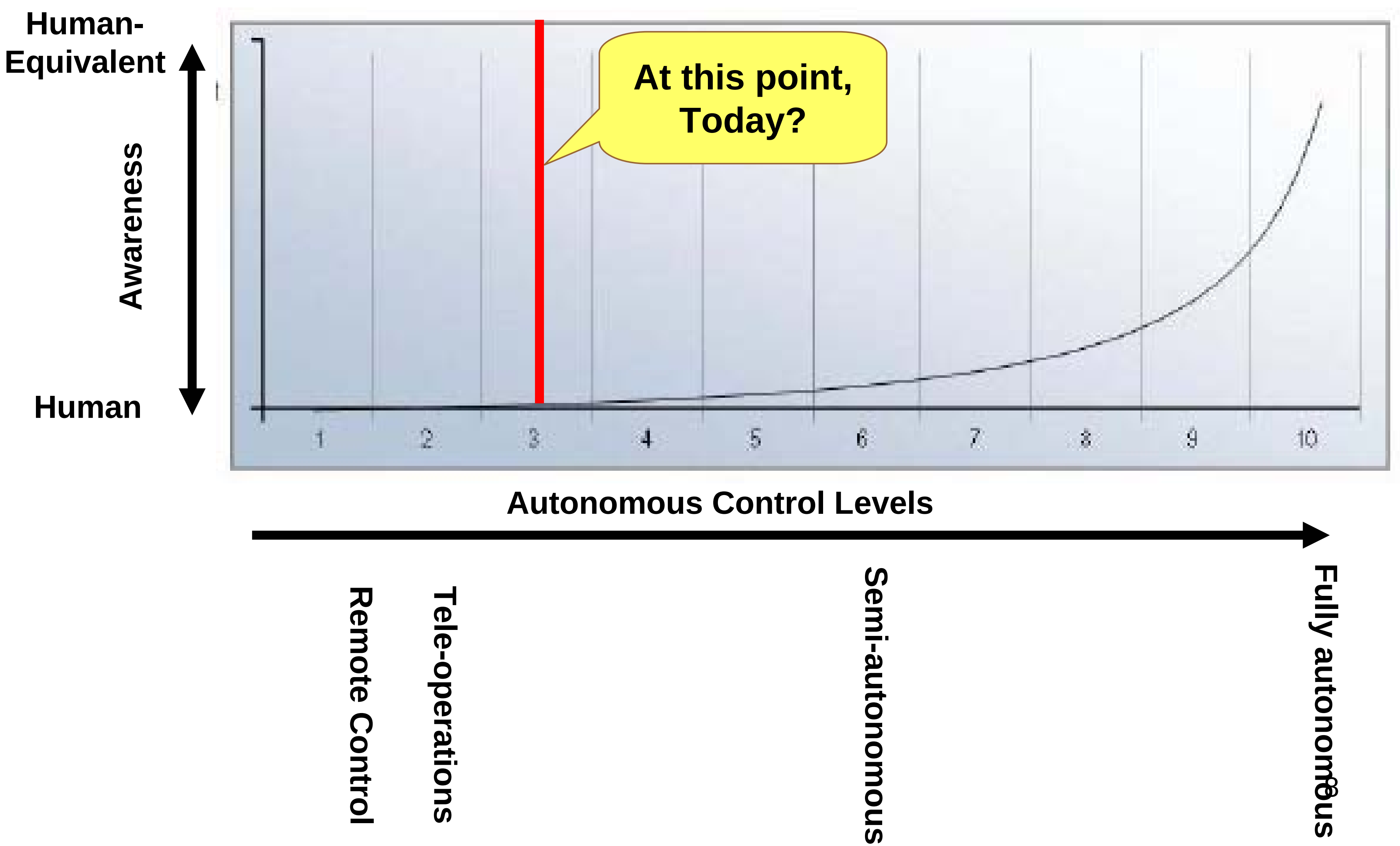


Talon Swords

UAV launch from MDARS

Raytheon UCAV

UMS Level of Awareness vs. Levels of Control



Background

- In FY05, the OSD Joint Robotics Program Coordinator for ground systems tasked Navy to:
  - Provide unifying safety guidance across all ground robotic projects
  - Establish initial safety precepts for ground robotic systems
    - Program Safety Guidance
    - Operational Guidance
    - System Design Safety Guidance
- Results briefed at 2005 ISSC

Background

- October 2005 briefed to OSD (DSOC ATP TF)
- ATP TF directed expansion of effort to include all Unmanned Systems (air, ground, and sea)
- Emphasized necessity of community input
  - Program Management
  - Design
  - Test
  - Operational
  - Safety
- Emphasized guidance vice direction

UMS Safety Objectives

- Focus the technical community on the System Safety needs for UMS
- Specifically:
  1. Understand the safety implications, including legal issues, associated with the rapid development and use of a diverse family of unmanned systems both within, and external to, the DoD.
  2. Establish and agree upon a standardized set of safety precepts to guide the design, operation, and programmatic oversight of all unmanned systems.
  3. Develop safety guidance, such as design features, hazard controls and mitigators, for the design, development, and acquisition of unmanned systems.

Approach

- ✓ **Involve technical community**
  - Six Workgroups
  - Approximately 80 technical experts
  - Government, Industry, Academia
- ✓ **Maximize Community Awareness**
  - March 2006 Workshop
    - 300 attendees
  - International Systems Safety Conference (ISSC)
  - Association of Unmanned Vehicles International (AUVSI)
  - NDIA Systems Engineering Conference
- ✓ **Obtain Feedback**
  - Web Page (http://www.ih.navy.mil/unmannedsystems)
  - Tech Panels & Reviews

✓ ISSC (31 July - 4 Aug 2006)
✓ AUVSI (29 – 31 Aug 2006)
✓ NDIA Systems Engineering (23 – 26 Oct 2006)
✓ Mr. Schaeffer's Systems Engineering Forum
✓ NDIA Systems Engineering (22 – 25 Oct 2007)

Road to Completion

✓ **Held Three Workshops**
- March 2006, Huntsville
- May 2006, Crystal City
- June 2006, Crystal City

✓ **Developed Safety Precepts**
- Programmatic safety precepts (6)
- Operational safety precepts (5)
- Design safety precepts (19)

✓ **Developed more detailed design safety “best practices” (safety precept clarification tables) (ongoing)**

✓ **USD (AT&L) issued the Guide on 17 July 2007**

Workshop Organization

✓ **Six Workgroups**

1. **Precept Development**
2. **Weapons Control**
3. **Situational Awareness**
   - **Human-Machine Interface**
   - **Machine-Machine Interface**
4. **Command and Control**
5. **States and Modes**
6. **Definitions/Common Taxonomy**

Unmanned Systems Management Team

- **Members**
  - Mr. Dave Schulte
  - Mr. Ed Kratovil
  - Mr. Jim Gerber
  - Ms. Rhonda Barnes
  - Mr. Danny Brunson
  - Mr. Josh McNeil
  - Mr. Bill Pottratz
  - Dr. Tom English
  - Mr. Steve Mattern
  - Mr. John Canning
  - Mr. Bob Schmedake

Workgroup Participants

Precepts:

Mr. Josh McNeil (Army)

- Mr. Woody Eischens (OSD)
- Mr. Clif Ericson (EG&G)
- Mr. Tom Garrett (Navy)
- Mr. Hui-min Huang (NIST)
- Mr. Bob Jacob (Navy)
- Mr. Mike Logan (NASA)
- Mr. Ranjit Mann (APT)
- Mr. Jack Marett (Westar)
- Mr. Charles Muniak (LMCO)
- Ms. Kristen Norris (AOT)
- Mr. Alan Owens (Air Force)
- Mr. Scott Rideout (USMC)
- Ms. Peggy Rogers (Navy)
- Mr. Craig Schilder (APS)
- Mr. Arthur Tucker (SAIC)
- Mr. Frank Zalegowski (Navy)
- Mr. Jim Zidzik (Navy)
- Mr. Don Zrebieck (Navy)

Weapons Control:

Mr. Bill Pottratz (Army)

- Mr. Scott Allred (USMC)
- Mr. Bill Blake (ATK)
- Dr. Craig Bredin (Westar)
- Ms. Mary Ellen Caro (Navy)
- Mr. John Deep (USAF)
- Mr. Jon Derickson (BAE)
- Mr. John Filo (Navy)
- Mr. Mark Handrop (USAF)
- Mr. Chris Janow (Army)
- LTCOL Emil Kabban (USAF)
- Mr. Dave Magidson (Army)
- Mr. Chris Olson (APT)
- Mr. Preston Parker (USAF)
- Mr. Jack Waller (Navy)
- Mr. Mike Zecca (Army)

Workgroup Participants

Situational Awareness:

Dr. Tom English (Navy)

- Dr. Julie Adams (Vanderbilt University)
- Ms. Alicia Adams-Craig (Army)
- Mr. Brad Cobb (Navy)
- Mr. Mike Demmick (Navy)
- Mr. Travis Hogan (GVI)
- Mr. Hui-Min Huang (NIST)
- Mr. Frank Marotta (Army)
- Mr. Aaron Mosher (Boeing)
- Mr. Mike Pessoney (APT)
- Mr. Owen Seely (Navy)
- Mr. Hoi Tong (Foster Miller)
- Mr. Bill Transue (EOD)
- Dr. Anthony Tvaryanas (USAF)
- Mr. Alan Weeks (iRobot)

Command and Control:

Mr. Steve Mattern (Apogen Technologies)

- Mr. Frank Albert (Navy)
- Mr. Billy Arnold (General Dynamics)
- Mr. John Canning (Navy)
- Mr. Steve Castelin (Navy
- Mr. Michael Dunn (Army)
- Ms. Rachael Fabyanic (Navy)
- Mr. Eugene Gonzales (Navy)
- Ms. Martha Meek (Army)
- Mr. Helmut Portmann (Navy)
- Mr. Ron Price (Army)
- Mr. Ed Spratt (Navy)
- Mr. Mike Zemore (Navy)

Workgroup Participants

States and Modes:

Mr. Bob Schmedake (Boeing)

- Mr. Mike Brown (EG&G)
- Mr. Danny Brunson (EG&G)
- Mr. Jim Butler (L3)
- Mr. Bill Edmonds (Army)
- Ms. Melissa Emery (APT)
- Mr. Bart Fay (Westar)
- Mr. Steve Hosner (Titan)
- Mr. Bob McAllister (USAF)
- Mr. Lynece Pfledderer (LMCO)
- Mr. Henry Zarzycki (Army)

Definitions/Common Taxonomy:

Mr. Danny Brunson (EG&G)

- Mr. Scottie Allred (USMC)
- Ms. Mary Ellen Caro (Navy)
- Mr. Bill Christian (APT)
- Mr. Brad Cobb (Navy)
- Mr. Clif Ericson (EG&G)
- Mr. Ranjit Mann (APT)
- Mr. Steve Mattern (Apogen Technologies)

Special Thanks "Heavy Lifters"

- ✓ **Mr. Jim Gerber**
- ✓ **Mr. Mike Demmick**
- ✓ **Mr. Josh McNeil**
- ✓ **Ms. Rhonda Barnes**
- ✓ **Mr. Danny Brunson**

Predator

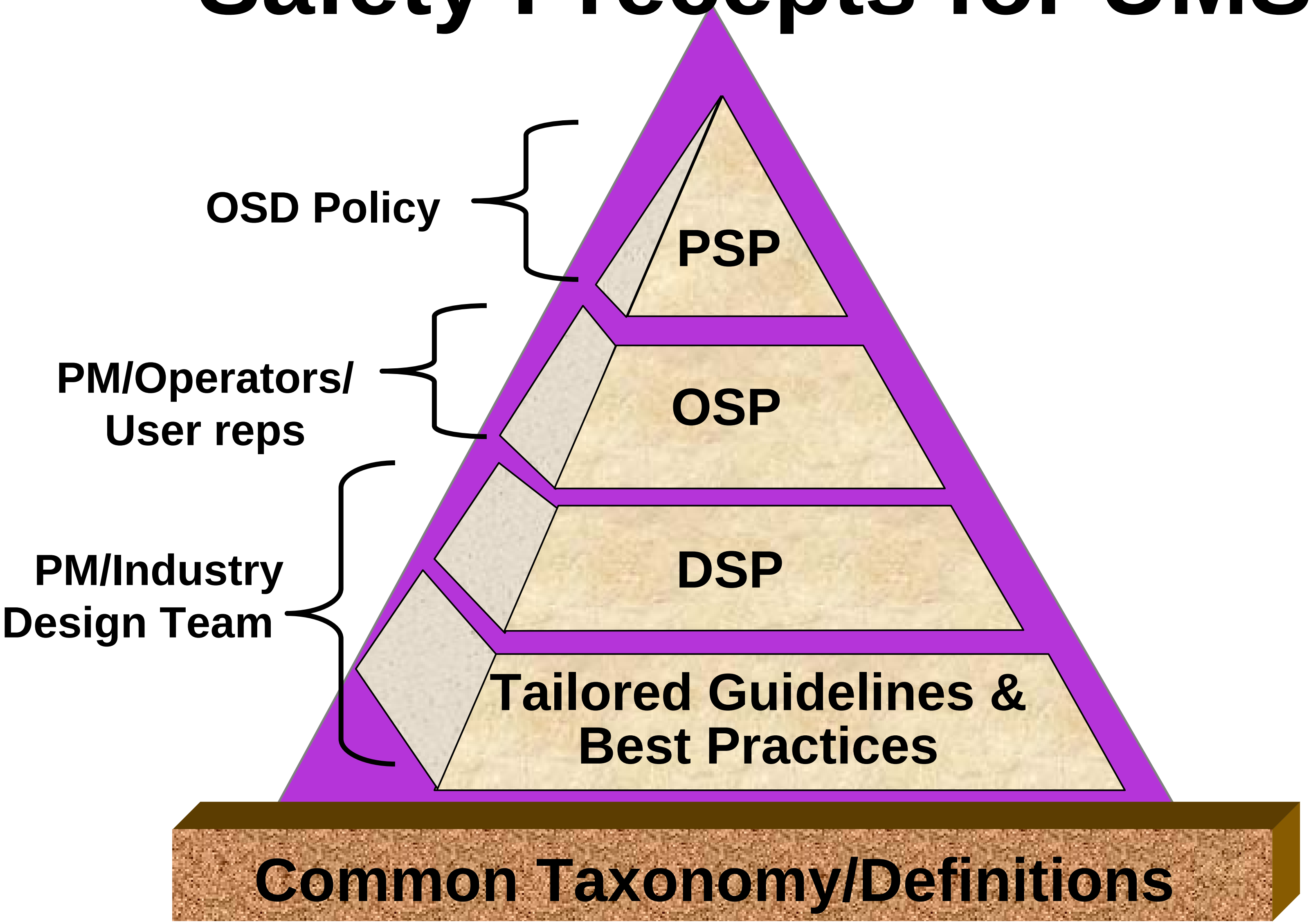
UMS Safety Precept Definitions

Programmatic Safety Precept (PSP) = **Program management principles & guidance that will help ensure safety is adequately addressed throughout the lifecycle process. (6)**

Operational Safety Precept (OSP) = **A safety precept directed specifically at system operation. Operational rules that must be adhered to during system operation. These safety precepts may generate the need for Design Safety Precepts. (5)**

Design Safety Precept (DSP) = **General design guidance intended to facilitate safety of the system and minimize hazards. Safety design precepts are intended to influence, but not dictate, specific design solutions. (19)**

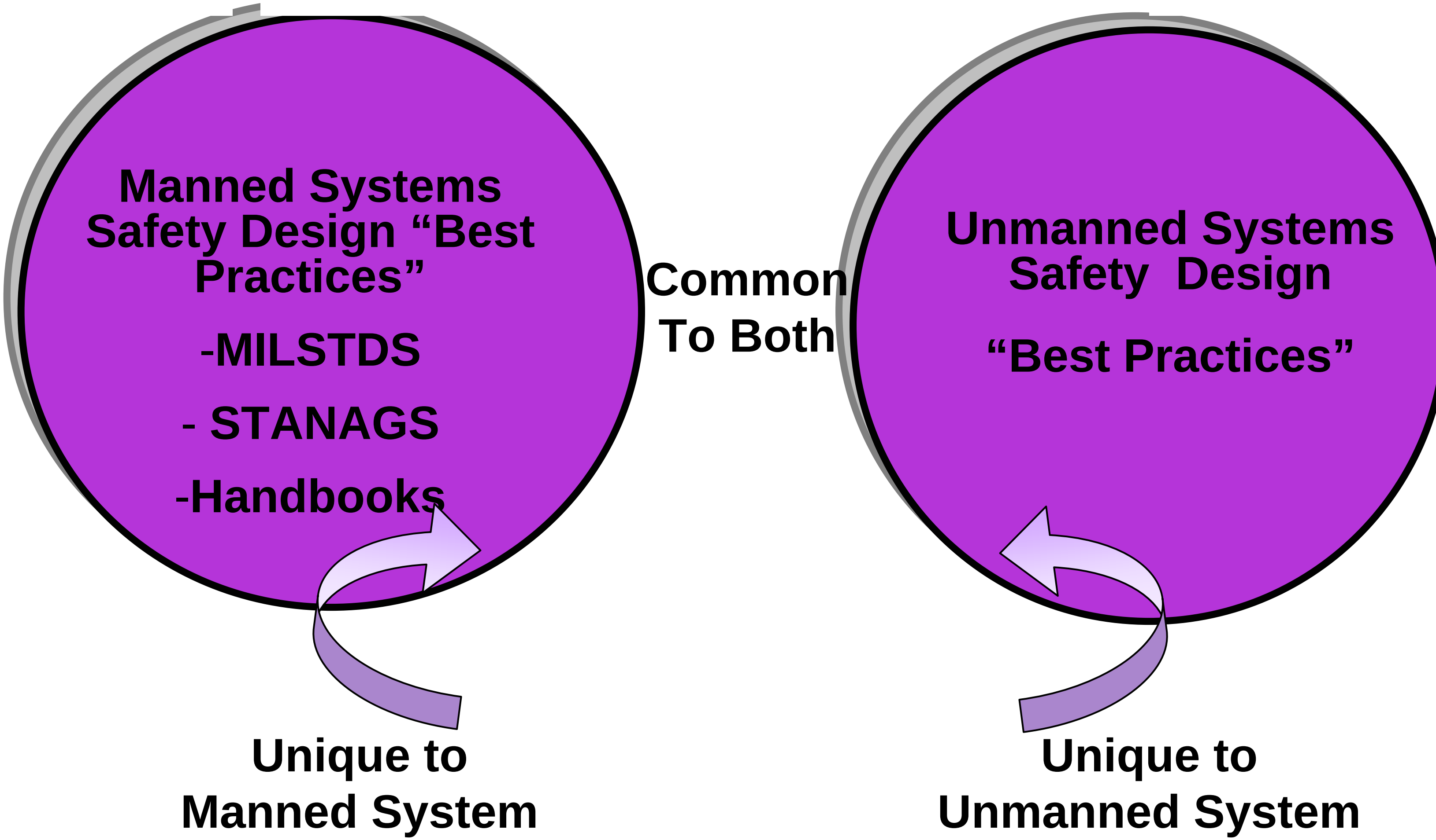
Safety Precepts for UMS



Provide PMs, designers, and systems safety managers with appropriate safety guidelines and best practices, <u>while maintaining PM's flexibility</u>

Safety Design Guidelines

Are we creating two sets of safety criteria: one for manned systems, and one for unmanned systems??



Creating another set of safety requirements? No

Safety Precepts

- ✓ Did not previously exist
- ✓ Evolved through an arduous, but thorough, systems engineering process over the past 2 years
- ✓ Separate study was performed to determine if current DoD and/or Service-specific policies addressed each of the safety precepts

Safety Precepts (cont'd)

The results of this study indicate:

- ✓ **Safety precept PSP-1 is completely addressed in both DoD and Service-specific policies.**
- ✓ **Three precepts (PSP-4, PSP-6, and DSP-1) are completely addressed in DoD policy and are partially addressed in Service-specific policies.**
- ✓ **Four precepts (PSP-3, DSP-11, DSP-12, and DSP-19) are partially addressed in both DoD and Service-specific policies.**
- ✓ **Nine precepts (PSP-2, OSP-1, OSP-3, OSP-5, DSP-7, DSP-13, DSP-14, DSP-16, DSP-18) are not addressed in DoD policy but are partially addressed in Service-specific policy.**
- ✓ **Twelve precepts (PSP-5, OSP-2, OSP-4, DSP-2, DSP-4, DSP-5, DSP-6, DSP-8, DSP-9, DSP-10, DSP-15 and DSP-17) are not addressed in DoD nor Service-specific policies.**
- ✓ **One precept DSP-3 was not mapped to policy.**

Final Product

UNMANNED SYSTEMS SAFETY GUIDE FOR DOD ACQUISITION
27 June 2007

- ✓ **Document contains descriptive and clarifying text for each precept.**
- ✓ **Includes definitions**
- ✓ **But,…comments/lessons learned are still requested for future updates**
  - **NOSSA Website (http://www.ih.navy.mil/unmannedsystems)**

USD (AT&L) UMS Memorandum

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

JUL 17 2007

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
UNDER SECRETARIES OF DEFENSE
COMMANDERS OF THE COMBATANT COMMANDS
ASSISTANT SECRETARY OF DEFENSE (NETWORKS & INFORMATION INTEGRATION)
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING
DIRECTOR, OPERATIONAL TEST AND EVALUATION
DIRECTOR, PROGRAM ANALYSIS AND EVALUATION
DIRECTORS OF THE DEFENSE AGENGIES

SUBJECT: Unmanned Systems Safety Guidance

In March 2006, the Defense Safety Oversight Council Acquisition and Technology Programs Task Force (ATP TF) initiated a study to identify the unique safety challenges of unmanned systems (UMSs), especially those systems carrying and deploying weapons in a joint environment. These safety challenges significantly increase as more UMSs are fielded and used in the same warfighting environment.

Using a collaborative process with experienced personnel from all Services, the ATP TF developed the "Unmanned Systems Safety Guide for DoD Acquisition" to provide programmatic, operational, and design guidelines to support the developme[nt] and fielding of safe UMSs. Please you use the Guide, found at http://www.acq.osd.mil/atptf/, to help identify and mitigate hazards and their associated risks for all UMS types.

For those UMSs that are ACAT 1D program, the UMS safety guidel[ines] ... special interest item during OSD Program Support Reviews. UMS-specific guidelin[es] have been added to the Defense Acquisition Program Support methodology to guide the evaluation of how successfully programs have engineered UMSs to reduce safety risks to acceptable levels.

Kenneth J. Krieg

"… use the Guide to help identify and mitigate hazards and their associated risks for all UMS types."

"For those UMSs that are ACAT 1D Programs, the UMS safety guidelines will be a special interest item during OSD Program Support Reviews."

Table of Contents

Programmatic Safety Precepts

PSP-1*: The Program Office shall establish and maintain a system safety program (SSP) consistent with MIL-STD-882.

PSP-2*: The Program Office shall establish unifying safety precepts and processes for all programs under their cognizance to ensure:

- **Safety consistent with mission requirements, cost and schedule**
- **Mishap risk is identified, mitigated and accepted.**
- **Each system can be safely used in a combined and joint environment**
- **That all safety regulations, laws, and requirements are met.**

PSP-3*: The Program Office shall ensure that off-the-shelf items (e.g., COTS, GOTS, NDI), re-use items, original use items, design changes, technology refresh, and technology upgrades (hardware and software) are assessed for safety, within the system.

Programmatic Safety Precepts
(Cont'd)

PSP-4*: The Program Office shall ensure that safety is addressed for all life cycle phases.

PSP-5: Compliance to and deviation from the safety precepts shall be addressed during all Milestone decisions and formal design reviews such as System Requirements Review (SRR), Preliminary Design Review (PDR), and Critical Design Review (CDR).

PSP-6*: The Program Office shall ensure UMS designs comply with current safety and performance criteria.

Note: While the document serves only as a guide, usage of the terms "shall" and "should" reflects the level of concern of the safety community

* Denotes applicability to both manned and unmanned systems.

Operational Safety Precepts

OSP-1: The controlling entity(ies) of the UMS should have adequate mission information to support safe operations.

OPS-2: The UMS shall be considered unsafe until a safe state can be verified.

OPS-3: The authorized entity(ies) of the UMS shall verify the state of the UMS, to ensure a safe state prior to performing any operations or tasks.

OSP-4*: The UMS weapons should be loaded and/or energized as late as possible in the operational sequence.

OSP-5*: Only authorized, qualified and trained personnel, with the commensurate skills and expertise using authorized procedures, shall operate or maintain the UMS.

Design Safety Precepts

DSP-1*: The UMS shall be designed to minimize the mishap risk during all life cycles phases.

DSP-2: The UMS shall be designed to only respond to fulfill valid commands from the authorized entity(s).

DSP-3: The UMS shall be designed to provide information, intelligence, and method of control (I2C) to support safe operations.

DSP-4*: The UMS shall be designed to isolate power until as late in the operational sequence as practical from items such as: a) Weapons, b) Rocket motor initiation circuits, c) Bomb release racks, or d) Propulsion systems.

DSP-5*: The UMS shall be designed to prevent release and/or firing of weapons into the UMS structure or other weapons.

DSP-6*: The UMS shall be designed to prevent uncommanded fire and/or release of weapons or propagation and/or radiation of hazardous energy.

DSP-7*: The UMS shall be designed to safely initialize in the intended state, safely and verifiably change modes and states, and prevent hazardous system mode combinations or transitions.

Design Safety Precepts
(Cont'd)

DSP-8*: The UMS shall be designed to provide for an authorized entity(s) to abort operations and return the system to a safe state, if possible.

DSP-9*: Safety critical software for the UMS design shall only include required and intended functionality.

DSP-10*: The UMS shall be designed to minimize single-point, common mode or common cause failures that result in high and/or serious risks.

DSP-11*: The UMS shall be designed to minimize the use of hazardous materials.

DSP-12*: The UMS shall be designed to minimize exposure of personnel, ordnance, and equipment to hazards generated by the UMS equipment.

DSP-13*: The UMS shall be designed to identify to the authorized entity(ies) the weapon being released or fired, but prior to weapon release or fire.

Design Safety Precepts

(Cont'd)

DSP-14*: In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.

DSP-15*: The firing of weapons systems shall require a minimum of two independent and unique validated messages in the proper sequence from the authorized entity(ies), each of which shall be generated as a consequence of separate authorized entity action. Both messages should not originate within the UMS launching platform.

DSP-16: The UMS shall be designed to provide contingencies in the event of safety critical failures or emergencies involving the UMS.

DSP-17: The UMS shall be designed to ensure safe recovery of the UMS.

DSP-18*: The UMS shall ensure compatibility with the test range environment to provide safety during test and evaluation.

DSP-19* The UMS shall be designed to safely operate within combined and joint operational environments.

Precept Clarification Table

Precept Number: Statement of the precept in the form of a requirement or general guidance.
Scope: Answers the question of "What?" the precept is for; often can be answered by "This precept addresses…."
Rationale: Answers the question of "Why?" the precept is required. This provides addition clarification of the intent of the precept.
Example: Provide as many clarifying explicit/real-world examples to demonstrate the issues and specific hazards the precept addresses.
Detailed Considerations: Answers the question of "How?" by providing details to assist with implementation of the precept. These are specific statements written in the form of a requirement or guideline which capture lessons learned and experience from other programs. Some of these considerations can be tailored for specific programs and incorporated into system specifications as safety requirements.

DSP-14 Loss of Command Link

DSP-14* In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.

Scope: This precept addresses the overall UMS design architecture and states and mode management in the event of unexpected loss or corruption of the command, control, and communications link (i.e. loss of data link, loss of command and control). The objective is for the UMS to be in the anticipated/expected state when recovery occurs. It is not the intended communication loss as in the case of underwater vessels or other fully autonomous UMS. The system should have the capability of storing a set of actions to take, or states to transition to, when the command link is lost. Predetermined means we have them in the plan. Expected means we intend that portion of the plan to go into effect for this condition. It applies to both the test and perational environments. This precept is related to DSP-3 and DSP-16.

Rationale: The intent of this precept is to assure that, by design; the controlling entity can anticipate the status, mode and state of the UMS, and any on-board weapons during a loss of link period, corruption of link, and the subsequent recovery of link. Determination of pre-determined and expected status should be based on analysis of such things as CONOPS, mission profile, and threat hazard assessments.

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Examples:

1. **A UAV would continue to fly out of range upon loss of command link if no contingency provisions are designed into the system.**

2. **A UAV has been directed upon loss of link to return to base. It currently has mission parameters loaded, weapons have been energized, and commanded to fire when communications link has been lost. The UAV responds to its mission parameters and is returning to base when it re-establishes communications….what state are the weapons in? Will it now execute its command to fire? If communications are lost and re-established, the UAV and weapons should default to an expected state.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Detailed Considerations:

- **The design should define state and mode transitions, including a desired and/or predictable course of action (such as move physically to a safe zone or crash in a safe zone), in the event of loss of link or intermittent command and control. The criteria for pre-determined and expected states and modes, and the courses of action include:**
  - **the UMS CONOPS and application;**
  - **the level of autonomy and level of control;**
  - **the operating environment (i.e. training, test, underwater, airborne, etc.);**
  - **the adequacy of communication link.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Detailed Considerations: (cont'd)

The UMS design should consider retention of pertinent mission information (such as last known state and configuration, etc.) for the UMS and the controlling entity(ies) to recover from loss of the communications link.

- **The UMS design must consider limiting the duration for which undelivered messages are considered valid.**
- **The UMS design must consider undelivered messages that can exist within the communication system.**
- **The UMS should ensure command messages are prioritized and processed in the correct sequence and in the intended state and mode.**
- **Reference NATO STANAG 4404 Section 7.4 and 8.3. DoD 8500.1 Section 4.1; and DoD 5000.1 Section E1.1.9.**

DSP-14 Loss of Command Link (cont'd)

DSP-14* **In the event of unexpected loss or corruption of command link, the UMS shall transition to a pre-determined and expected state and mode.**

Existing Policy:

Service	Document	Section	Comment
Navy	NAVSEA SWO20-AH-SAF-10	Section 14.8.3	Text partially references precept.

Need your help in identifying any other existing policy documents

Protector Unmanned Surface Vehicle

Summary

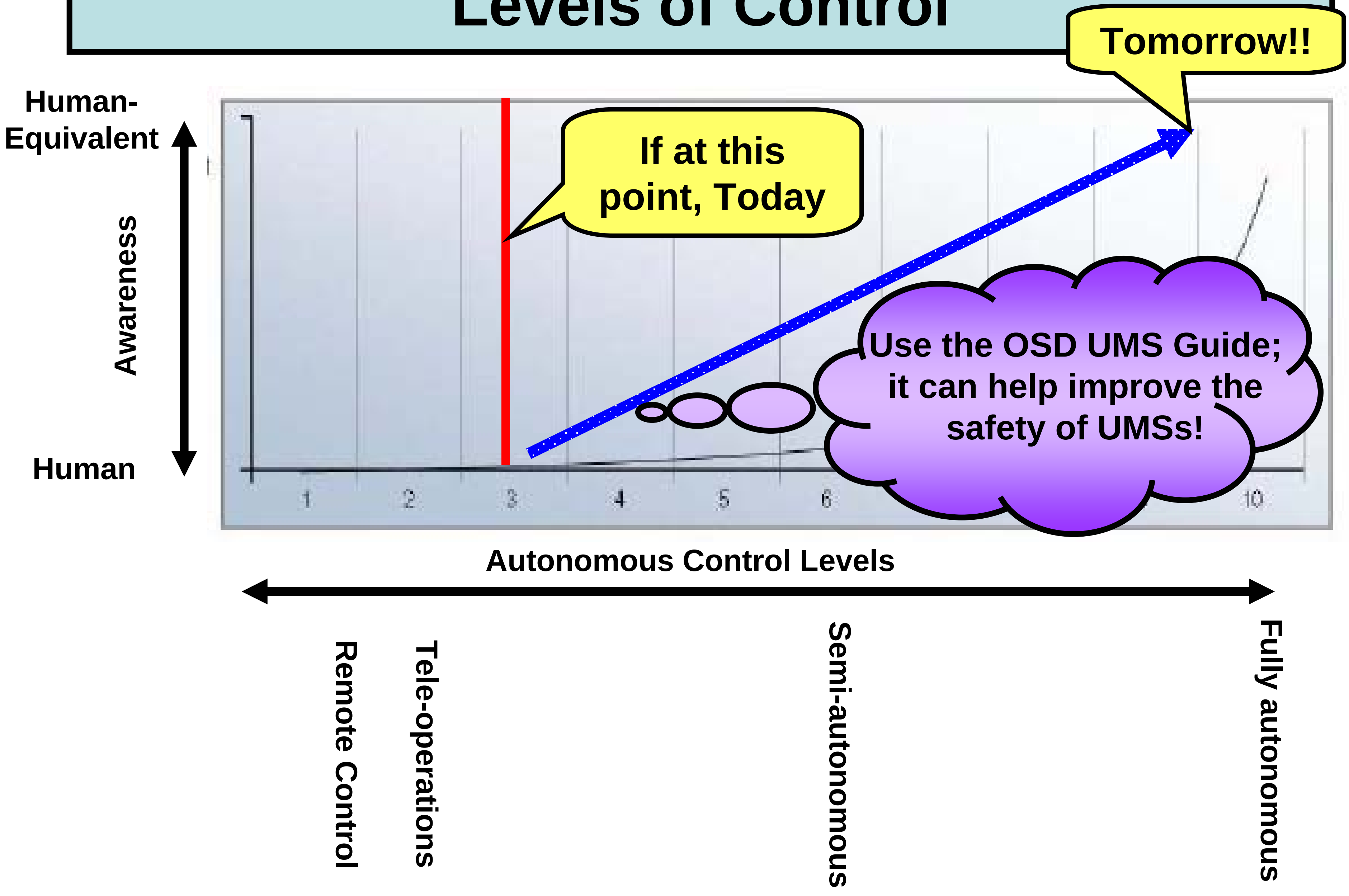
- ✓ **Held three workshops (March, May, June 2006)**
- ✓ **Government/industry/academia teams developed draft safety precepts, rationale & design guidance**
  - ➢ **All Services and numerous UMS program office reps participating**
- ✓ **Briefed**
  - ➢ **International Systems Safety Conference (2005, 2006 and 2007)**
  - ➢ **AUVSI (August 2006)**
  - ➢ **NDIA Systems Engineering (October 2006 and 2007)**
- ✓ **Comments Requested**
  - ➢ **NOSSA Website (http://www.ih.navy.mil/unmannedsystems)**

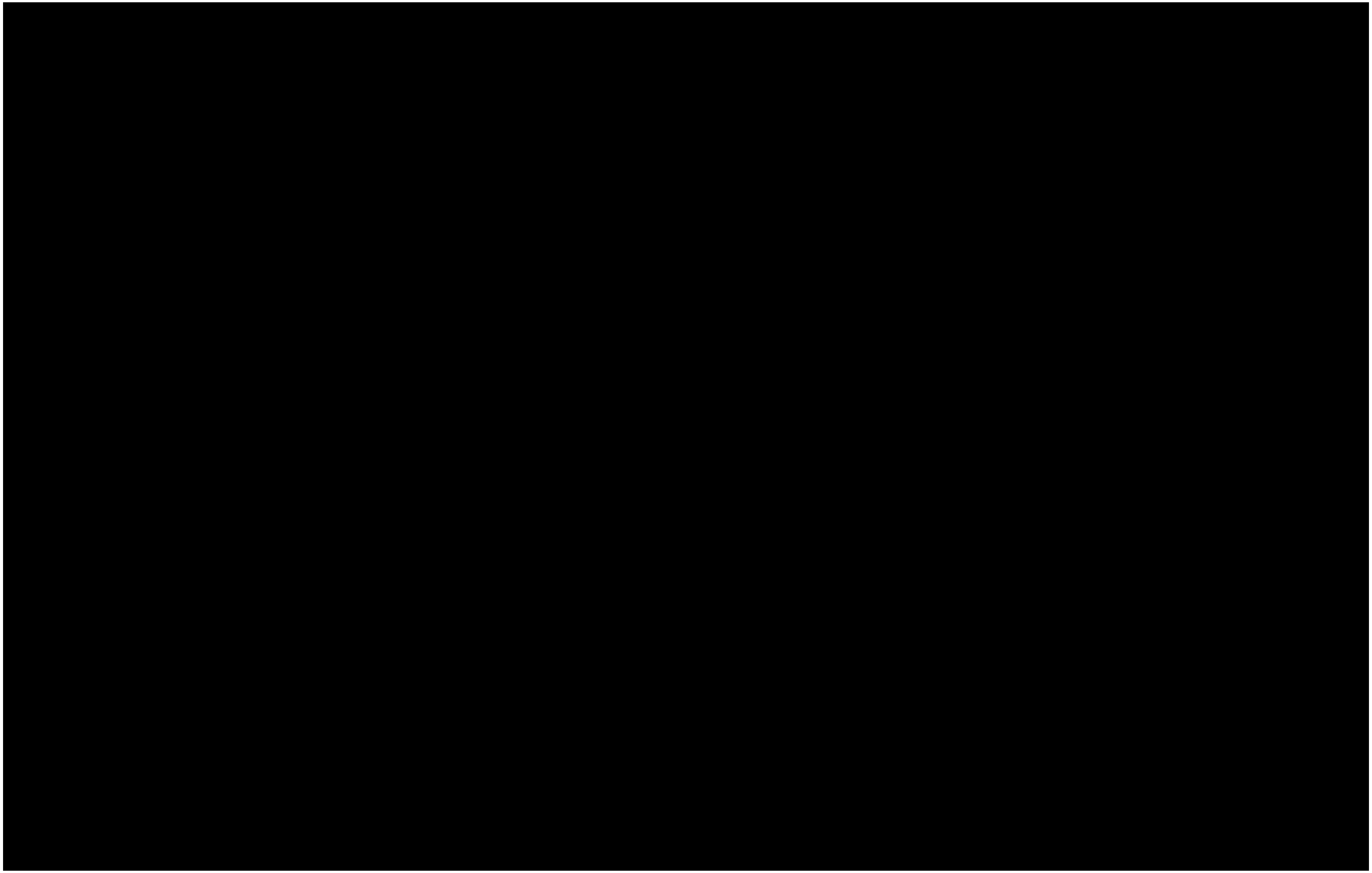
Summary (cont'd)

USD (AT&L) Memorandum of 17 July 2007

- ✓ Forwarded the Guide to the Service Secretaries and other major DoD components as an enclosure to a memo strongly endorsing the use of the Guide for all UMS acquisitions.
- ✓ The Undersecretary directed that the UMS Safety precepts in the Guide be a special interest item for ACAT 1D Program Support Reviews.
- ✓ The Guide has been posted on the OSD ATP-TF Website at http://www.acq.osd.mil/atptf/
- ✓ Next steps:
  - Convert the Guide to a MIL-HDBK
    - Handbook is for guidance
    - Service ownership
    - Facilitate periodic updates
    - Formatting completed September 2007
    - Final Handbook completion 3rd Qtr 2008
  - Update Policy and Service Directives to address UMS Precepts, where appropriate. (Remember, 12 Safety Precepts not addressed at all in policy.)

UMS Level of Awareness vs. Levels of Control





Navy WSESRB Command Vehicle


Safety of Unmanned Systems
Sponsored by
DSOC ATP TF
Questions and Comments

CMMI for Services:

Re-introducing the CMMI for Services Constellation

NDIA Systems Engineering Conference
October 22-25, 2007

Craig R. Hollenbach
Northrop Grumman Corporation

Brandon Buteau
Northrop Grumman Corporation

Drew Allison
Systems and Software Consortium Inc.

Frank Niessink
DNV-CIBIT

Agenda

- CMMI-SVC News
- Overview of the draft CMMI for Services (CMMI-SVC)
  - What is the CMMI?
  - Why is the CMMI-SVC needed?
  - How are services different?
  - What is the basis for the CMMI-SVC model?
  - What is the scope and content of the CMMI-SVC?
- Feedback to date
  - What was the result of the expert review?
  - What was the experience of the pilot projects?
- Next Steps
  - What is the schedule?
  - How can I participate?

CMMI Steering Group to Address CMMI for Services

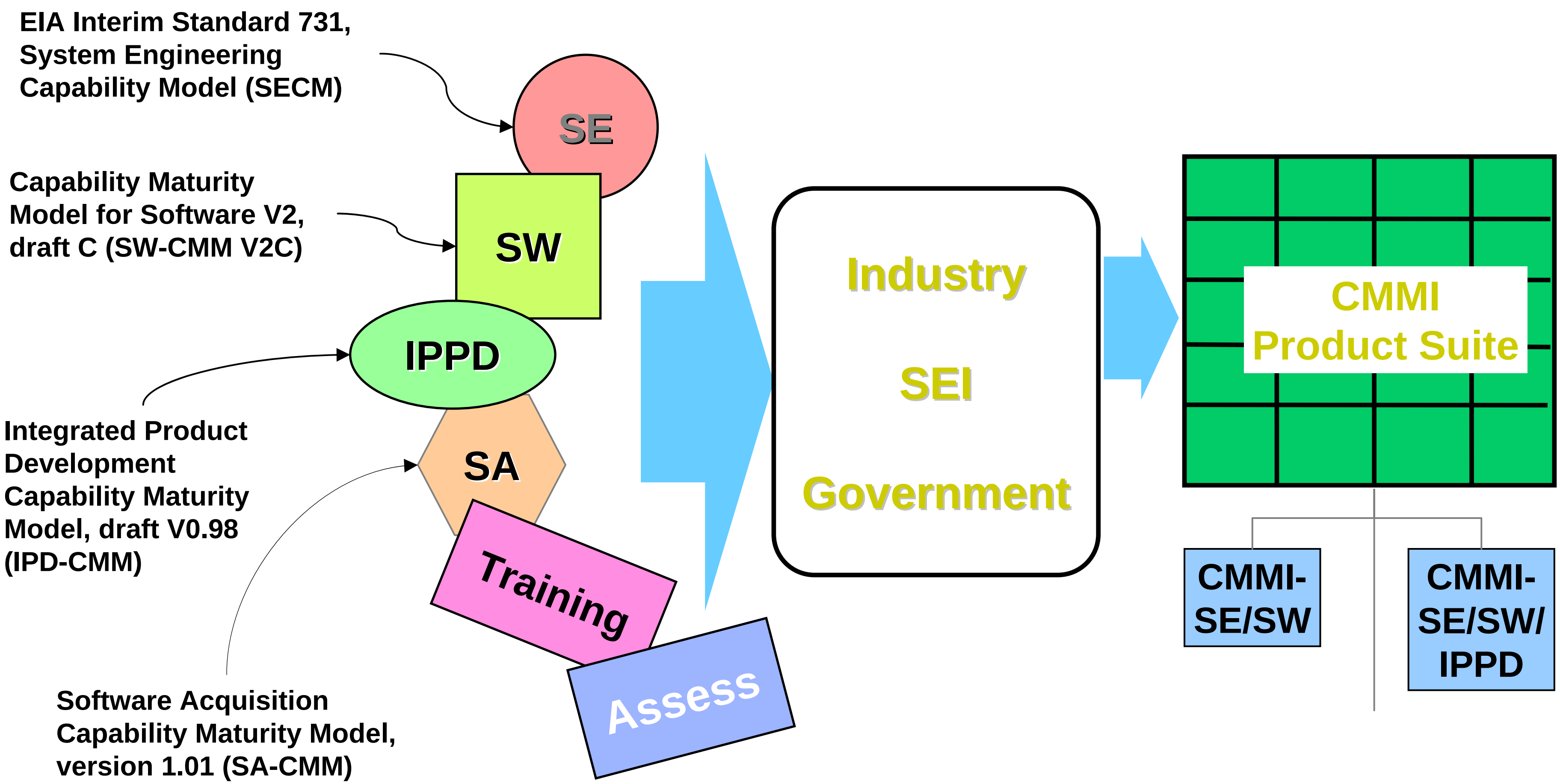
- There was a serious concern that concurrent development of the CMMI-ACQ and CMMI-SVC models would stress the SEI resources needed to deliver the CMMI-ACQ model on time. Now that CMMI-ACQ is almost released, the SEI resources are available to go forward with the CMMI-SVC.
- The CMMI-SVC team will address past Steering Group concerns at their Nov meeting and present a plan to complete development.

What is a Capability Maturity Model (CMM)?

- A conceptual framework for structuring, understanding, and evaluating the capability and maturity of an organization’s processes
  - more than a laundry list of best practices
  - more than a collection of benchmarks and metrics
- A tool that enables meaningful, in-depth organizational assessment
  - internally
  - externally
- A map that guides practical process improvement and institutionalizes it
  - How to you get from *here* to *there* and *stay there*?

What is the CMMI?

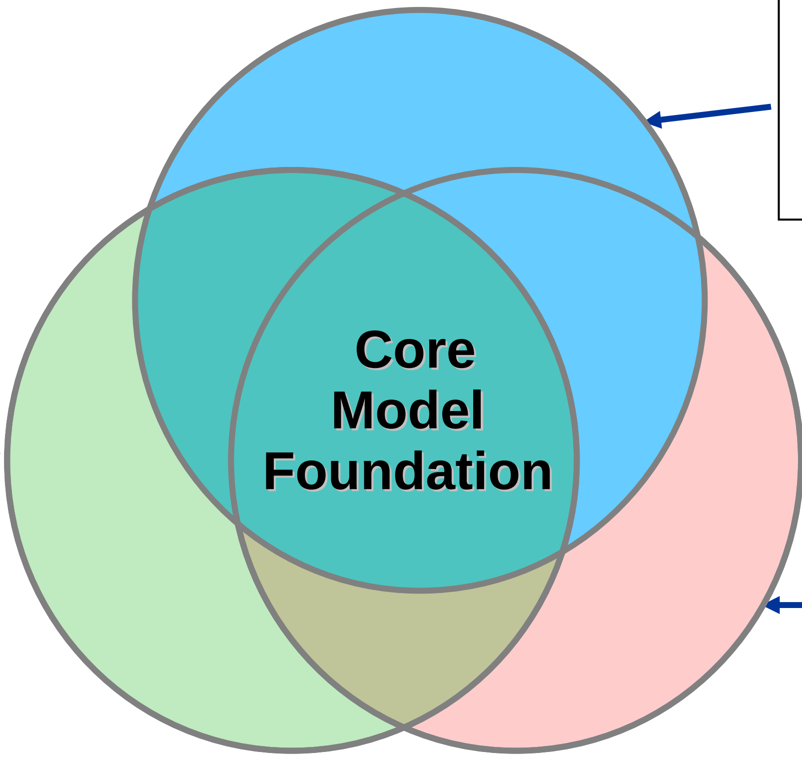
- The CMM Integration[SM] (CMMI) of multiple CMMs into a single unified framework



Three complementary constellations

CMMI-DEV
provides guidance for measuring, monitoring, and managing development processes

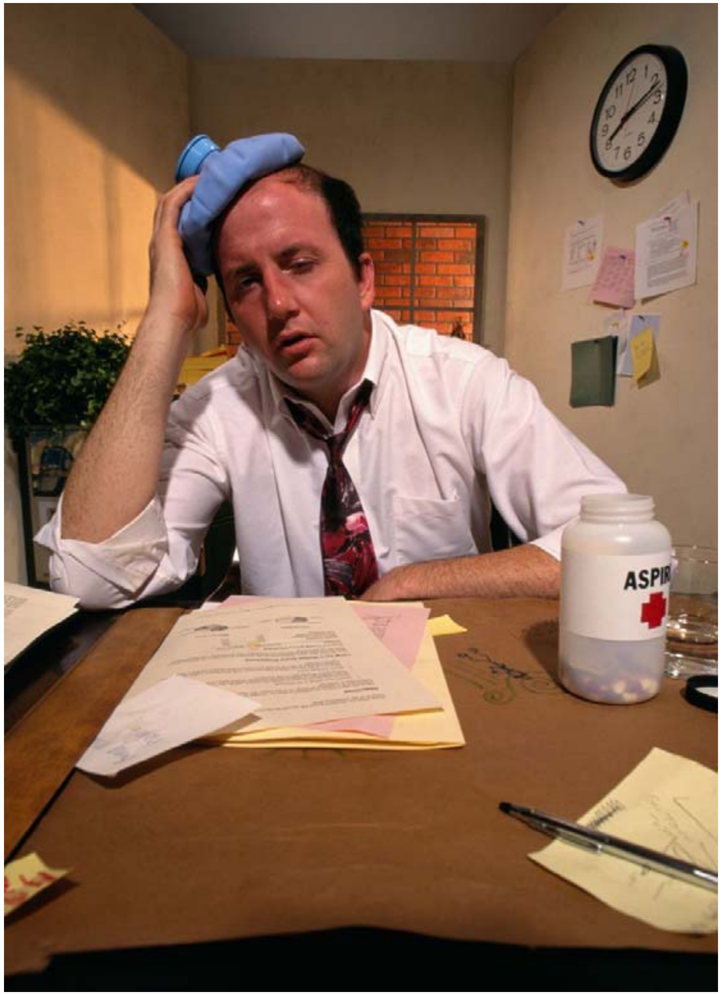
CMMI-SVC
provides guidance for those providing services within organizations and to external customers



CMMI-ACQ
provides guidance to enable informed and decisive acquisition leadership

Courtesy of the SEI

Why is CMMI for Services (CMMI-SVC) needed?



- Customer discontent
- Service society
- Legislation
- Government and industry trends

How are services different?

- Services form a distinctive category of products
  - A service is an intangible, non-storable product
  - What makes a service intangible or non-storable?
    - Customer desires a situation or state (e.g., to have high network availability) rather than a tangible artifact
    - Provider delivers value without allowing the customer independent, unrestricted means to generating/employing that value (e.g., leasing vehicles)
    - Product delivery requires continuing application of labor (e.g., operation of a facility)
- Services imply customer/provider relationships governed by service agreements
  - Service and non-service products may be delivered as part of a single agreement (e.g., training that includes hardcopy materials)
- Services are often delivered via the operation of a service system

Service system

- A necessary concept for understanding the effective delivery of services
- An integrated and interdependent combination of processes, resources, and people that satisfies service requirements.
- Portions are not delivered to the customer or end-user as part of service delivery
- Portions may remain owned by the customer or end-user before service delivery begins and after service delivery ends.
- Encompasses everything required for service delivery, including work products, processes, infrastructure, consumables, and customer resources.

What is the scope of CMMI-SVC?

- Covers practices required to manage, establish, and deliver services, in four process area categories
  - Project (service) management
  - Process management
  - Service support
  - Service establishment and delivery
- Intended to match the scope of the definition of services
- Broad applicability to a range of service domains
  - Information technology, engineering, defense, transportation, finance, health care
- Staff augmentation services need careful consideration
  - How do you evaluate process improvement for processes over which you have no control?

CMMI-SVC Process Areas

- **Process Management**
- Organizational Innovation and Deployment (OID)
- Organizational Process Definition (OPD)
- Organizational Process Focus (OPF)
- Organizational Process Performance (OPP)
- *Organizational Service Management* (OSM)
- Organizational Training (OT)

- **Service Support**
- Causal Analysis and Resolution (CAR)
- Configuration Management (CM)
- Decision Analysis and Resolution (DAR)
- Measurement and Analysis (MA)
- *Problem Management* (PRM)
- Process and Product Quality Assurance (PPQA)

Service Establishment and Delivery

- *Incident and Request Management* (IRM)
- *Service Delivery* (SD)
- *Service System Development* (SSD)
- *Service Transition* (ST)

Project Management

- *Capacity and Availability Management* (CAM)
- Integrated Project Management (IPM)
- Project Monitoring and Control (PMC)
- Project Planning (PP)
- Requirements Management (REQM)
- Risk Management (RSKM)
- Quantitative Project Management (QPM)
- *Service Continuity* (SCON)
- Supplier Agreement Management (SAM)

Services-specific PAs

Process Area	Maturity Level	Specific Goals/ Practices
Capability and Availability Management (CAM)	3	2 / 6
Incident and Request Management (IRM)	2	2 / 6
*Organizational Service Management (OSM)**	3	2 / 7
Problem Management (PRM)	3	2 / 7
*Service Continuity (SCON)**	3	3 / 10
Service Delivery (SD)	3	2 / 7
*Service System Development (SSD) **	3	3 / 12
Service Transition (ST)	3	3 / 12

* optional process areas (independent named additions)

CMMI-SVC Level 2 PAs

- Incident and Request Management
  - To ensure the timely resolution of requests for service and incidents that occur during service delivery
- Requirements Management
  - Extended from the Core Model Foundation with an additional goal
  - To include the establishment and maintenance of written agreements between service providers and customers on service requirements and service levels.
- Six other level 2 PAs from the CMF

CMMI-SVC Level 3 PAs

- Capacity and Availability Management
  - To plan and monitor the effective provision of resources to support service requirements
- Problem Management
  - To prevent incidents from recurring by identifying and addressing underlying causes of incidents
- Service Delivery
  - To deliver services in accordance with service agreements
- Service Transition
  - To deploy new or significantly changed service systems while managing their effect on ongoing service delivery

Optional PAs for CMMI-SVC Level 3

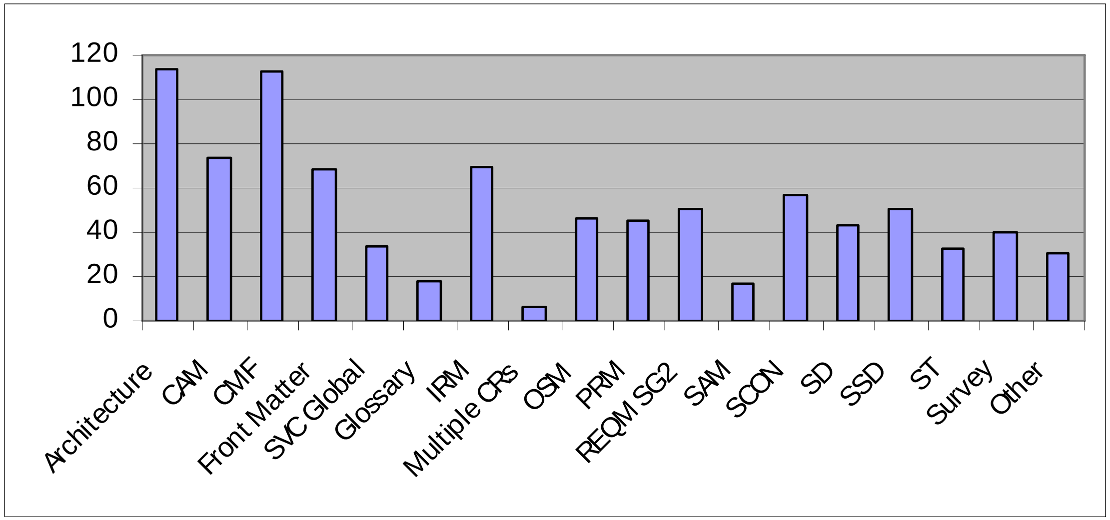
- Organizational Service Management
  - To establish and maintain standard services that ensure the satisfaction of the organization's customer base
- Service Continuity Management
  - To establish and maintain contingency plans for continuity of agreed services during and following any significant disruption of normal operations
- Service System Development
  - To analyze, design, develop, integrate, and test service systems to satisfy existing or anticipated service agreements

What was the result of the expert review?

- An expert review was held Jan 23 - Mar 23, 2007
  - 500+ reviewers, representing:
    - 50 companies,
    - 14 DoD organizations,
    - 4 academic institutions, and
    - 7 professional, governmental, or research centers
    - Reviewers included SEI transition partners
- Response showed strong interest in CMMI-SVC
  - 900+ change requests compares favorably to those received for CMMI-DEV
  - 50 survey responses to architectural questions

What was the result of the expert review? (more)

- Reviews commented mostly on CMM-SVC architecture & Common Model Foundation material
- CRs were distributed equally among categories related to SVC PAs
- CMMI-SVC team has analyzed all architectural CRs; most have a proposed resolution
- CRs showed excellent depth of insight and rich informative content



Sample Survey Responses

- The service practices that are covered in CMMI-SVC will enable service organizations to provide more effective support to their customers.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
78.9%	8.8%	12.3%

- The material in CMMI-SVC yields a useful adaptation of CMMI best practices as they relate to service deployment.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
66.7%	14.0%	15.8%

- CMMI-SVC does not impose constraints (derived from the needs of a specific service or market segment) that would limit or prevent other organizations from adapting the model to their own specific needs.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
55.6%	29.6%	27.8%

- The CMMI-SVC is easy to understand and apply to a service organization.

Strongly Agree or Agree	Neutral	Disagree or Strongly Disagree
42.8%	27.8%	29.6%

What was the experience of the pilot projects?

- Planned pilots were postponed
- CMMI-SVC participating companies piloted the model internally
- Characteristics of the piloted organizations:
  - Most had implemented CMMI-DEV
  - Some had separate ITIL and ISO 20000 initiatives
  - Most are moving towards integration under CMMI umbrella
- The pilots represented the following service domains:

Company	Service Domains
SSCI	IT Application Operations & Support
DNV-CIBIT	Banking
Northrop Grumman	Logistics, HR, IT, Applications O&M

What did the pilots see as benefits?

- Improved quality of services
- Encouraged a disciplined culture for service management
  - Better management visibility into services
  - Fewer surprises
  - Fosters process improvement
- Less Interpretation issues (& appraisal expense) than with CMMI-DEV
- Applying a CMMI process to the services brought credibility and buy-in from stakeholders
- Increased sharing between development and services communities
  - Common processes
  - Standard terminology
  - Integrated process improvement standards and models
- Encouraged end-to-end lifecycle process approach helping to identify service requirements, ease deployment issues, reduce stove-piped groups, and improve efficiencies of support-related groups (IT Applications)

What did the pilots see as challenges?

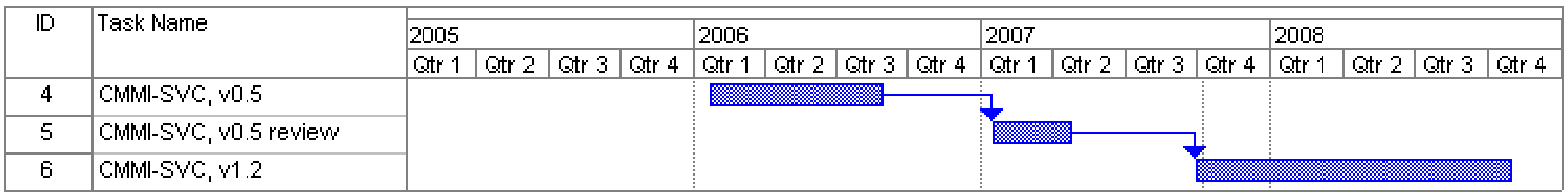
- Obtaining funding in environments that are primarily LOE-based
- Differences in terminology between development and services
  - Terms like “Project” (funding period), “Product” (service), “Work Product”, “Product Component”, “Requirement”
  - Interpreting CMMI’s “project” term for services
- No standard life-cycle definition for services
- Instilling project management culture in services
  - Weak in using requirements for planning and negotiating resources and activities
- Ownership of service system components not as clear
- Release management and deployment to non-standardized, constantly changing environments
- Finding CMMI-knowledgeable individuals who also know services
- Integrating process groups and assets
- Services where customer and provider share resources and processes
- Staff augmentation

Issues to Address

- What is the business case for the CMMI-SVC?
- What distinguishes CMMI-SVC from CMMI-DEV (v1.2) and other models?
- What are the characteristics of service providers and how are they represented in the CMMI-SVC?
- Can the broad spectrum of services be governed by a single model?
- How will the Services Sector be engaged?
- What are the impacts to small businesses?
- How will CMMI-SVC be used with other CMMI products?

What is the schedule?

- CMMI-SVC team will meet to review additional requirements and re-plan remaining work (early Nov)
- Detailed schedule is pending
- A preliminary estimate for release of CMMI-SVC, v1.2 is 4^{th} quarter 2008



How can I participate?

- Get more information about CMMI-SVC
  - CMMI web page - http://www.sei.cmu.edu/cmmi/
  - CMMI for Services Public Workspace (http://bscw.sei.cmu.edu/bscw/bscw.cgi/0/424939) contains:
    - Draft CMMI-SVC model, v0.5
    - Information on joining CMMI-SVC information email list
- Review draft CMMI-SVC release
- If already experienced in CMMI, consider piloting the model
- Other opportunities may exist as a result of the CMMI-SVC re-planning effort; watch CMMI-SVC public workspace for updates

Backup

References

- CMMI - http://www.sei.cmu.edu/cmmi/cmmi.html
- ITIL - http://www.ogc.gov.uk/index.asp?id=2261
- itSMF - http://www.itsmf.com/
- BS 15000 - http://www.bs15000.org.uk/
- COBIT - http://www.isaca.org/
- ITSCMM - http://www.itservicecmm.org/
- Interpreting Capability Maturity Model Integration (CMMI) for Operational Organizations, Brian P. Gallagher, Technical Note, CMU/SEI-2002-TN-006, April 2002
- Interpreting Capability Maturity Model Integration (CMMI) for Service Organizations – a Systems Engineering and Integration Services Example, Mary Anne Herndon, SAIC, et al, Technical Note, CMU/SEI-2003-TN-005, November 2003
- Services CMMI Public Website - http://bscw.sei.cmu.edu/bscw/bscw.cgi/0/424939

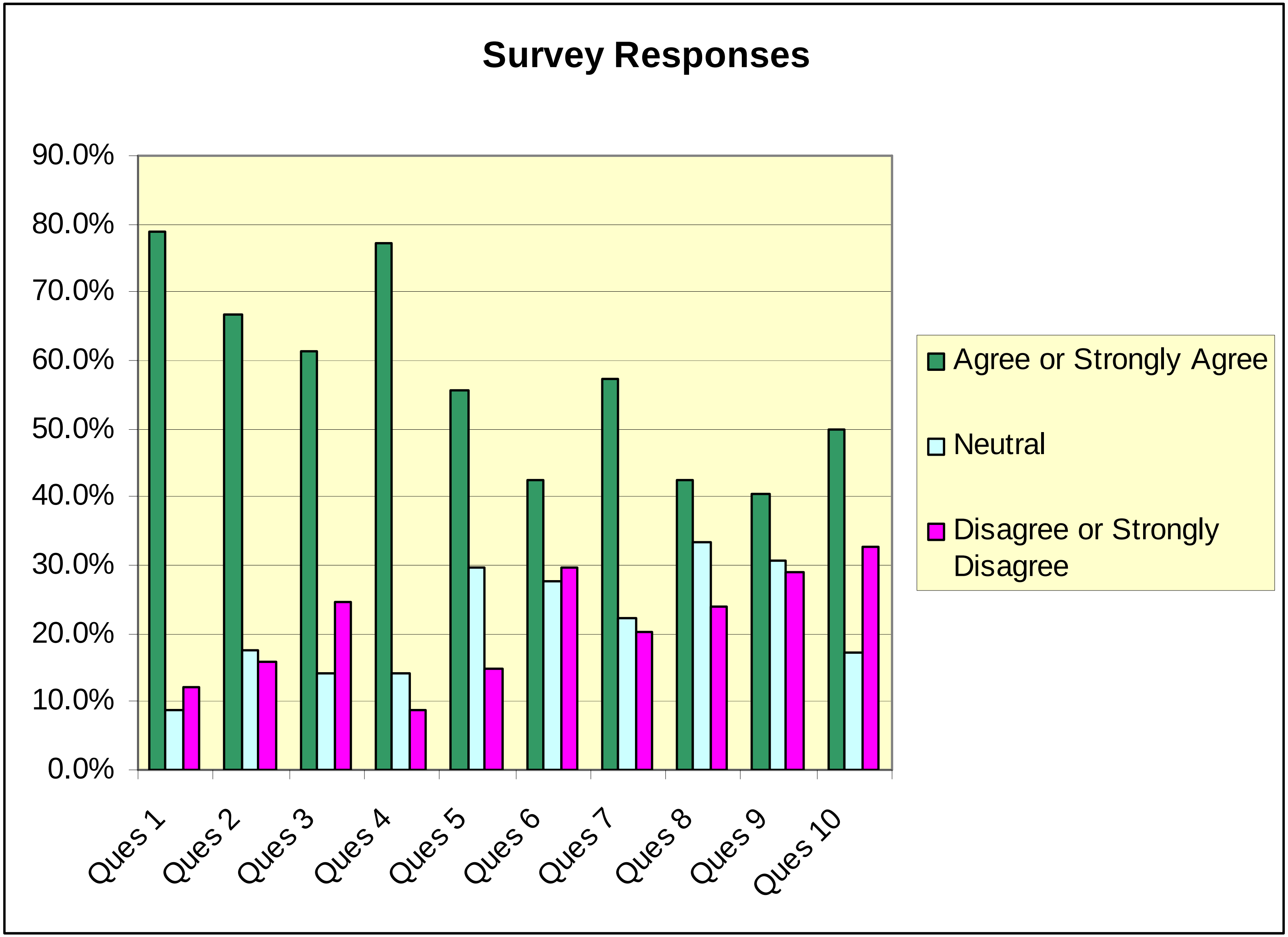
Who is working on CMMI-SVC?

- Development Team
  - Craig Hollenbach (Northrop Grumman) - Lead
  - Roy Porter (Northrop Grumman)
  - Brandon Buteau (Northrop Grumman)
  - Lynn Penn (Lockheed Martin)
  - Frank Niessink (DNV/CIBIT)
  - Jerry Simpson (SAIC)
  - Drew Allison (SSCI)
  - Eileen Forrester (SEI)
  - Barbara Tyson (SEI)
  - Eileen Clark (SRA)
- Other contributors
  - Jeff Zeidler (Boeing)
  - Rich Raphael (Mitre)
  - Joanne O'Leary (SEI)

General Survey Questions

1. The service practices that are covered in CMMI-SVC will enable service organizations to provide more effective support to their customers.
2. The material in CMMI-SVC yields a useful adaptation of CMMI best practices as they relate to service deployment.
3. The CMMI-SVC appropriately uses the CMMI framework.
4. CMMI-SVC includes process areas that must be satisfied for process improvement and institutionalization.
5. CMMI-SVC does not impose constraints (derived from the needs of a specific service or market segment) that would limit or prevent other organizations from adapting the model to their own specific needs.
6. The CMMI-SVC is easy to understand and apply to a service organization.
7. The process areas in CMMI-SVC cover all significant service-specific requirements and effectively reflect activities that a service organization should be accomplishing.
8. Additions and amplifications that exist in other models and are also used within the CMMI-SVC constellation are appropriate.
9. Notes and examples in CMMI-SVC clearly apply to service organizations and meet their specific needs.
10. References in PAs to related process areas are clear and consistently applied.

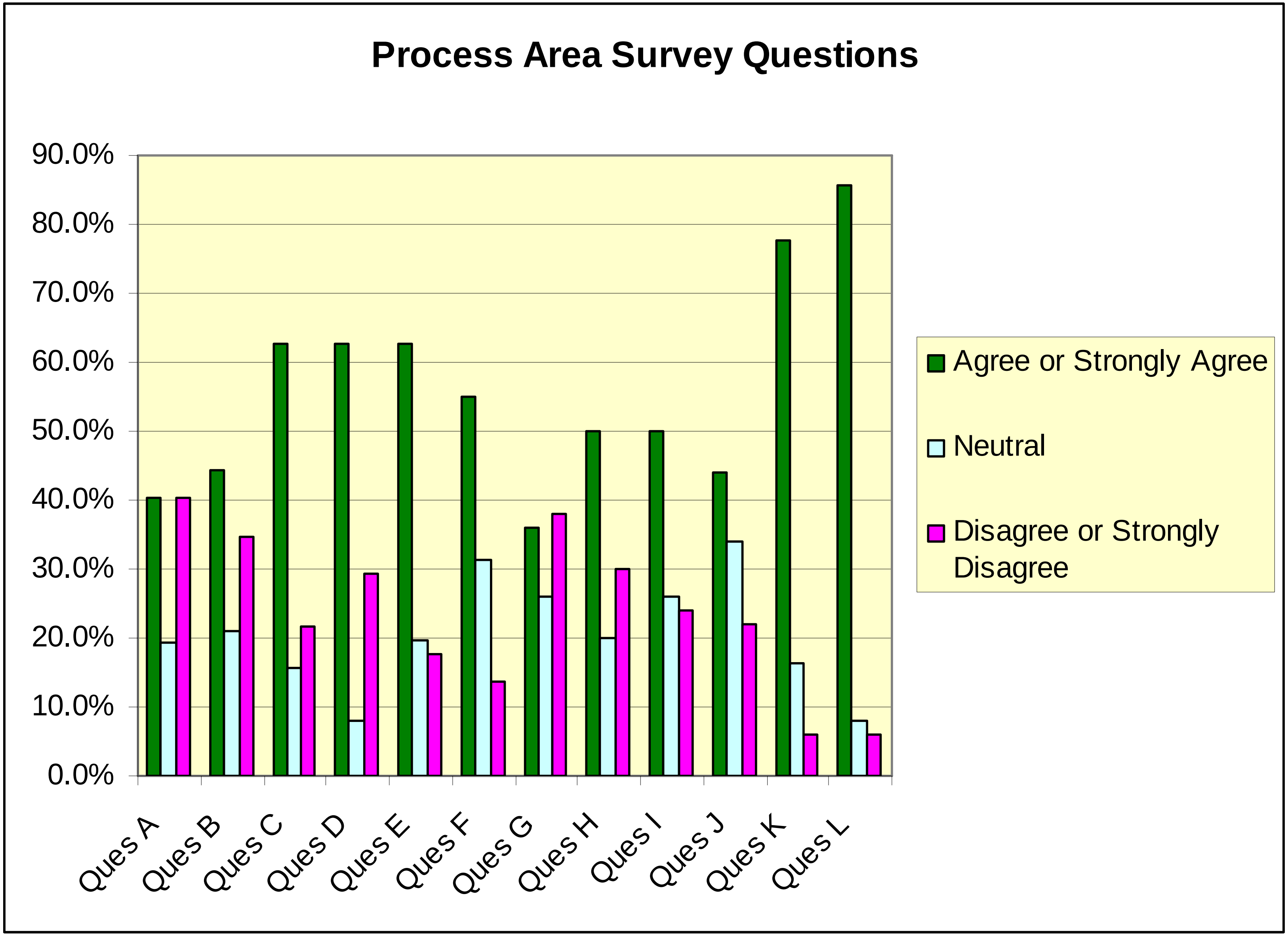
Results to General Survey



Process Area Questions

A. Problem management practices that are common within the service industry are appropriately addressed in the process area Problem Management and are distinguished from the practices in the Causal Analysis and Resolution process area.
B. The Project Management category is the most appropriate classification for the Service Continuity Management and Capacity and Availability Management process areas.
C. The Process Management category is the most appropriate classification for the Organizational Service Management process area
D. The practices within the Service Continuity process area should build upon the practices within the Risk Management process area similar to the manner in which the Integrated Project Management process area builds upon maturity level 2 project management practices.
E. The Service System Development process area must be required for an organization to be a mature service organization.
F. The specific practices in the Service System Development process areas are presented with the appropriate rigor and detail for a mature service organization.
G. The Project Monitoring and Control process area adequately addresses service level management.
H. Material about the collection of customer satisfaction information is adequately covered as a specific practice in Organizational Service Management (an optional process area) and as informative material in the Service Delivery process area.
I. Maintenance found in the Service Delivery process area is adequately differentiated from product maintenance covered by CMMI-DEV.
J. The IPPD addition is as appropriate or as applicable for CMMI-SVC as it is for CMMI-DEV and should be added.
K. The Supplier Agreement Management process area is appropriate both for organizations with tangible products and service organizations with supplier agreements solely for services.
L. The Supplier Agreement Management process area should be required to reach maturity level 2 for service organizations with supplier agreements solely for services (as it is for organizations with suppliers of tangible products).

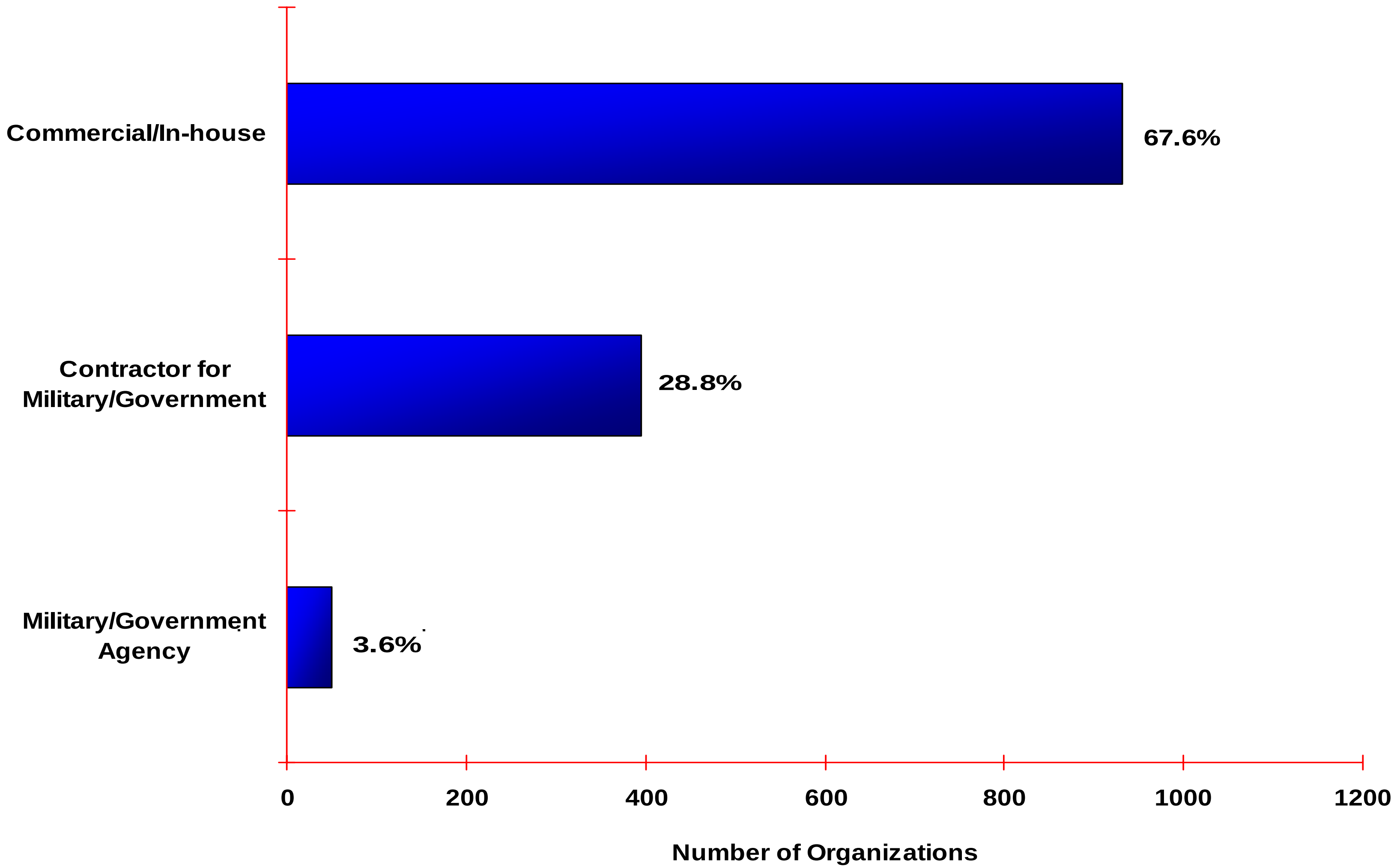
Process Area Survey Questions



What is the relationship between CMMI-SVC and ITIL?

- CMMI-SVC complements ITIL
  - Summarizes ITIL best practices into a small set of specific practices.
  - Reuses about 80% of the current CMMI model, allowing users to leverage their investments in development-based process training, improvements, and infrastructure to service-based offerings.
  - Provides an industry-accepted maturity model, helping organizations to plan and track their incremental progress toward high maturity.
  - Uses the same SCAMPI appraisal method that is used with the current CMMI model, allowing organizations to leverage appraisal expertise, preparation methods, and selected artifacts.

Who uses CMMs?



Courtesy of the SEI

Why do CMMs *really* matter?

Improvements	Median	Data Count	Low	High
Cost	34%	29	3%	87%
Schedule	50%	22	2%	95%
Productivity	61%	20	11%	329%
Quality	48%	34	2%	132%
Customer Satisfaction	14%	7	-4%	55%
ROI	4.0 : 1	22	1.7 : 1	27.7 : 1

- N = 30, as of August 2006
- Organizations with results expressed as change over time

Courtesy of the SEI

Anatomy of an Award Winning Safety Program: A Case Study of the SSGN OHIO Class Conversion Safety Program

Mike Parulis (for) Thomas Cook

&

Ricky Milnarik

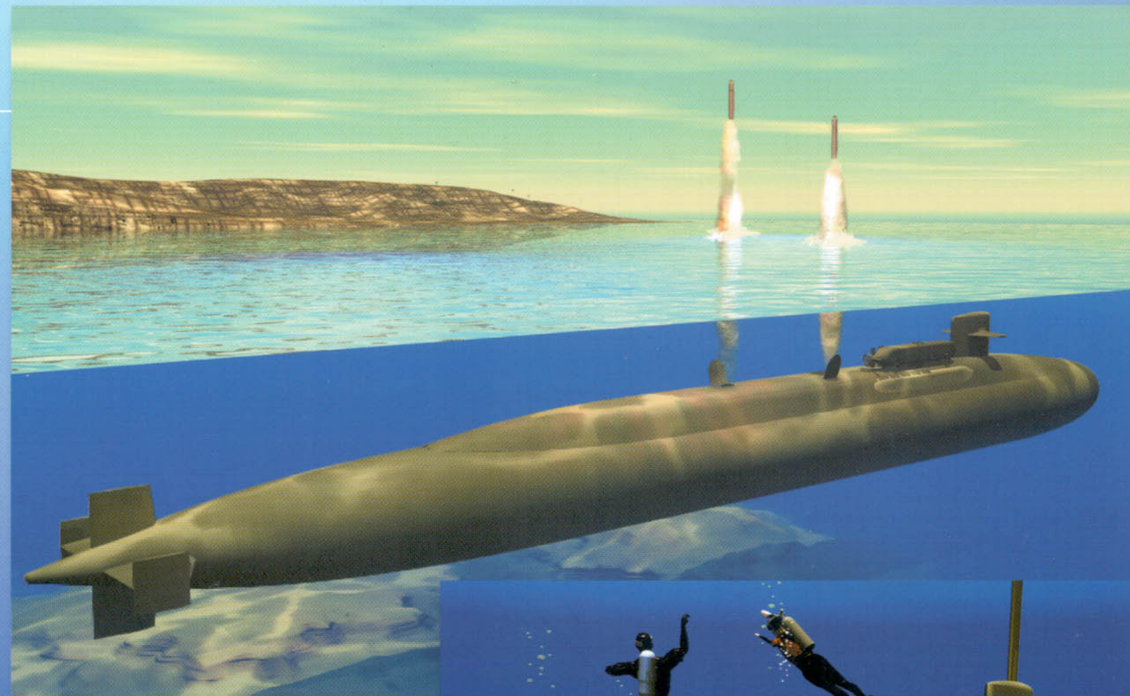
NAVSEA
NAVAL SEA SYSTEMS COMMAND

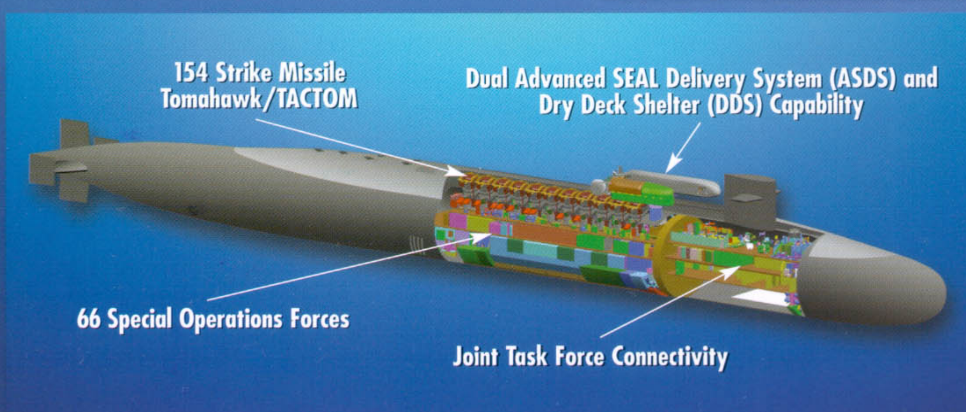
GENERAL DYNAMICS
Electric Boat

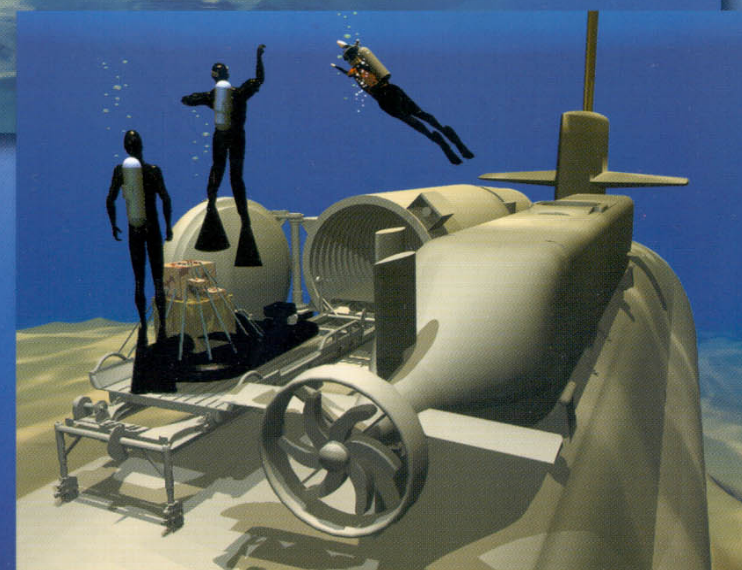
SSGN

Ship Characteristics

Length	560 ft
No. of SOF Personnel	66 to 102
No. of VLS Missiles	Up to 154
DDS/ASDS Capability	Dual
Speed	20+ knots

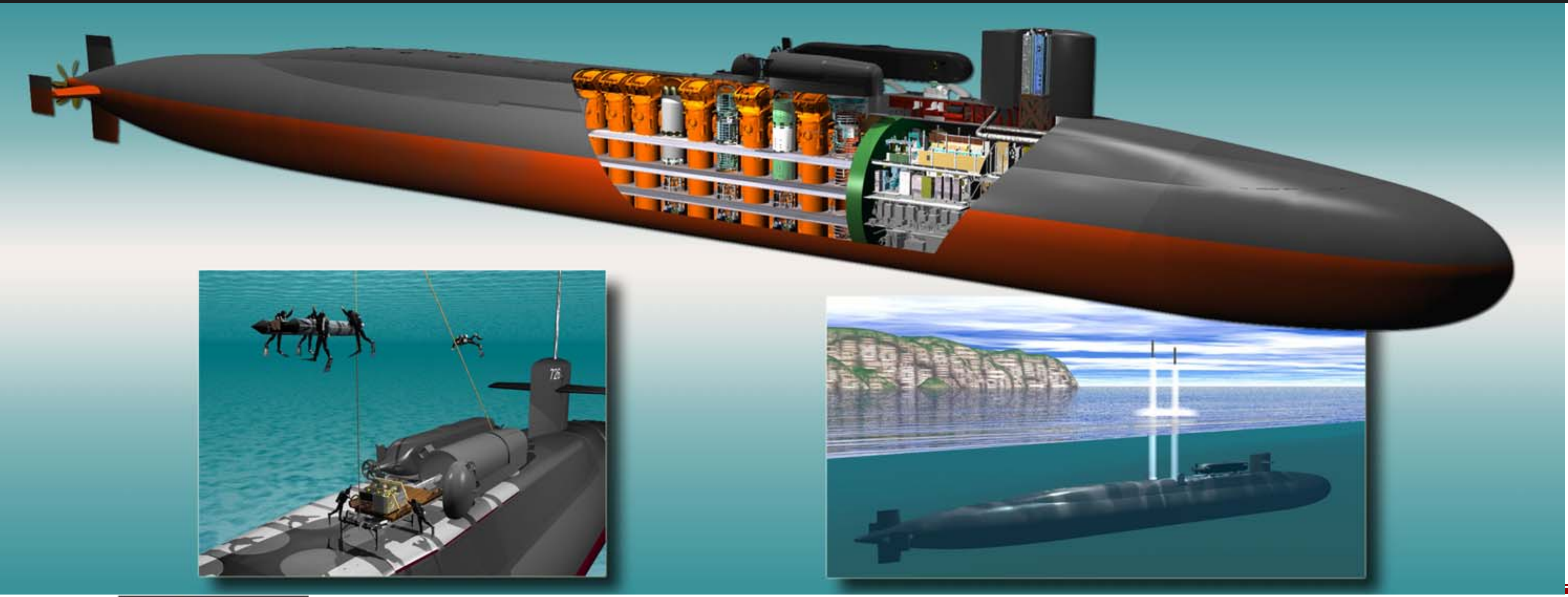






GENERAL DYNAMICS
Electric Boat

- 154 TOMAHAWK Missiles
- 66 Special Operations Forces (SOF) for more than 60 Days
- 2 Dry Deck Shelter / Advanced SEAL Delivery System
- 8 Modular SOF Storage Canisters
- Battle Management Center:
- Joint Connectivity and Organic Command & Control Capability
- Communications suite has double the antennas of an SSN
- SOF Habitability & Training Facilities
- SEASUB – Lock-In/Lock-Out, Ordnance Package



NAVSEA
NAVAL SEA SYSTEMS COMMAND

GENERAL DYNAMICS
Electric Boat

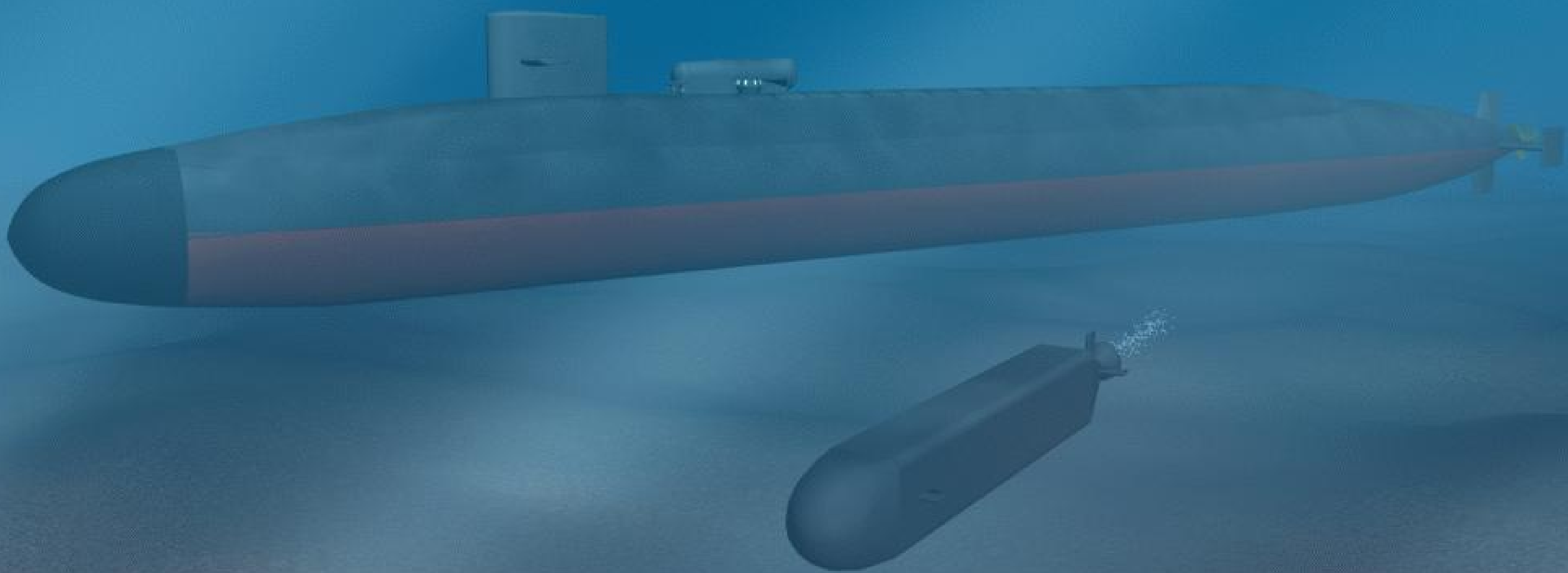
SSGN Conversion

Parallel conversion at Puget Sound Naval Shipyard & Norfolk Naval Shipyard

NAVSEA NAVAL SEA SYSTEMS COMMAND

GENERAL DYNAMICS Electric Boat

A NAVSEA (Program Office) Perspective

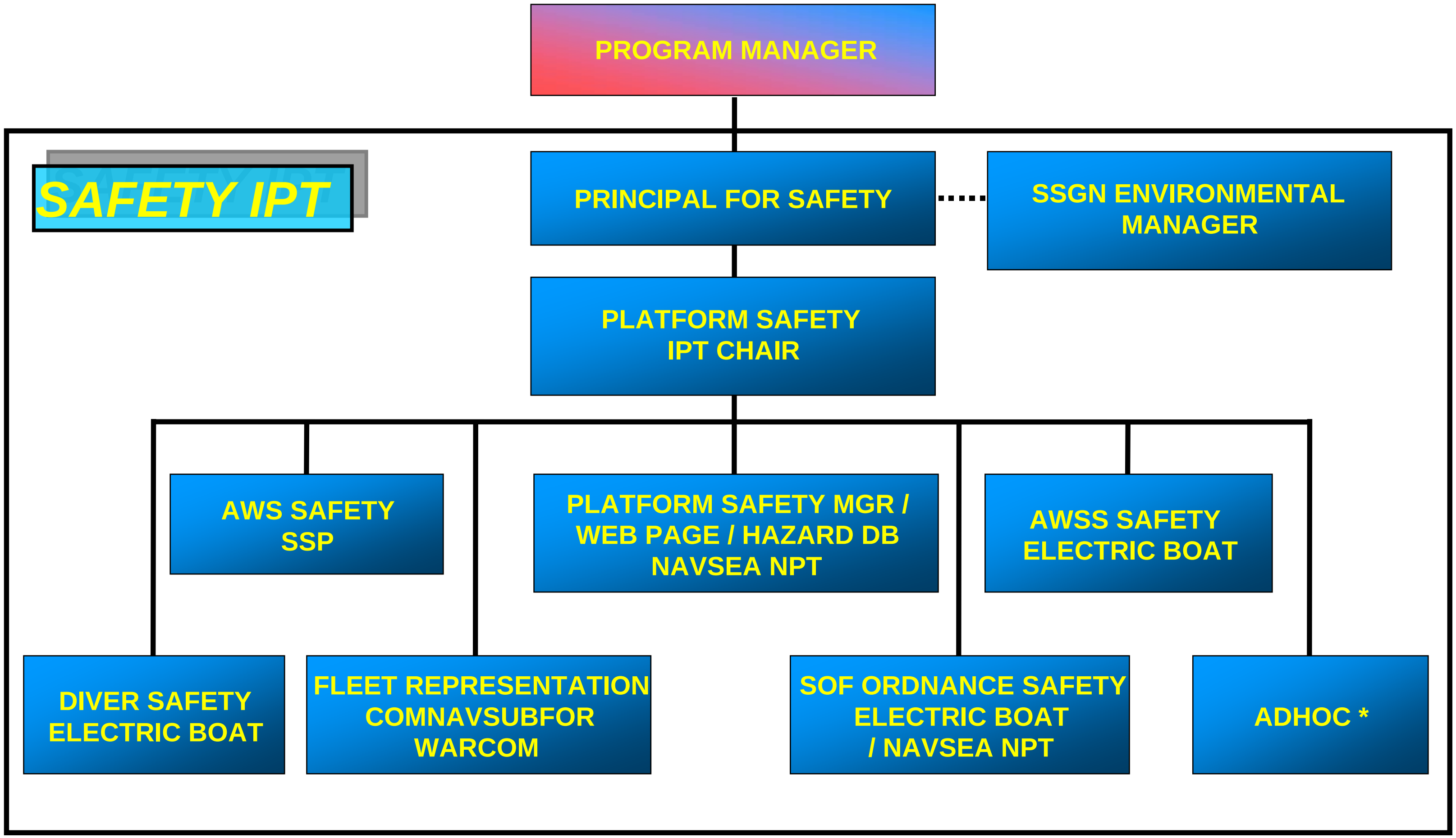


Mike Parulis for Thomas Cook
NAVSEA PMS398T12G

Introduction

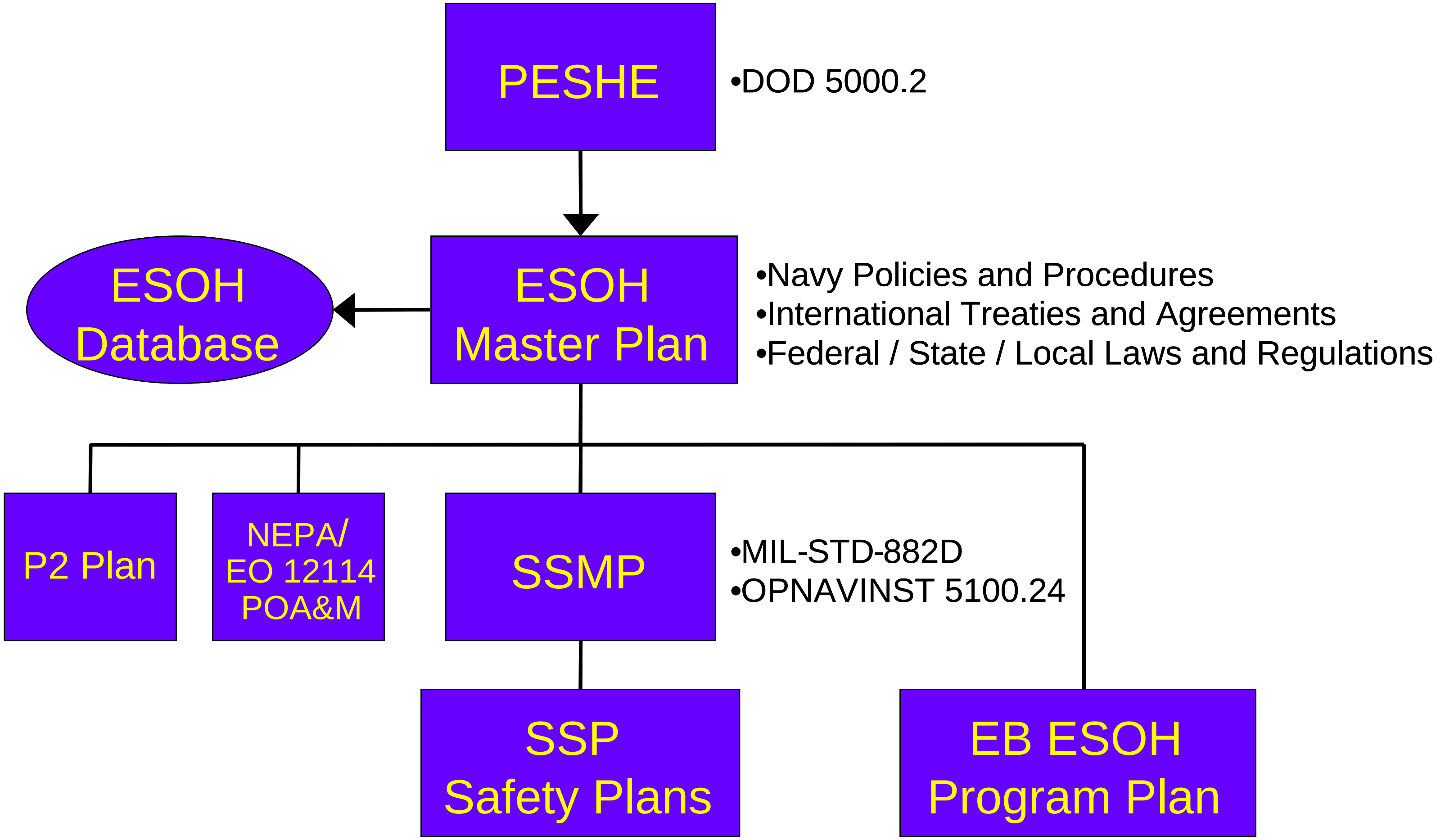
NAVSEA assembled multi-disciplinary teams that developed and implemented ESOH management programs whose goals were to incorporate life cycle ESOH compliance into design and construction

SSGN Conversion ESOH



*** *ADHOC* - Participants as necessary (i.e., NOSSA / WSESRB, Legacy, Shipboard Shock, Packaging, Handling and Transportation)**

SSGN Conversion ESOH



SSGN Conversion ESOH

- MIL-STD-882D requirement
  - Allows flexibility
    - Multiple Government Agencies
    - Prime Shipbuilder Contractor
    - Several other Contractors
  - Each organization has own safety plan
    - All are in accordance with program office plan
    - Each organization plan is tailored for specific “way of doing business”

NAVSEA NAVAL SEA SYSTEMS COMMAND

GENERAL DYNAMICS Electric Boat

SSGN Conversion ESOH

- Integrated Product Team (IPT) Process
  - Not exactly an IPT process, but encompasses the open communication
    - Open expression of ideas (safety and process)
    - Members encouraged to voice concerns
    - Seeks consensus on programmatic issues and processes
  - Buy-In by the program office, Principal for Safety,and the individual (contractor or government) identifying the Hazard
    - Identification – at least three signatures
    - Acceptance – at least four signatures

SSGN Conversion ESOH

- Performance based Specification instead of detailed requirements
  - As Principal for Safety
    - Insist on end-results
      - Hazards/Impacts identified openly (i.e., don't suppress)
      - Hazards/Impacts mitigated in a consistent manner
        - » Each organization follows the same MIL-STD-882 logic for severity and probability (Initial & Final)
    - Do not dictate manner to reach end-results
      - Analyses conducted by each organization as per their processes

NAVSEA Summary

- Program Support
  - Continuous funding
  - Adequate safety manning
- Safety IPT Independence
- Contributing organizations staffed by experience safety engineers
  - Strategic Systems Programs (e.g., TRIDENT)
  - Naval Undersea Warfare Center
  - Naval Air Systems Command
  - Electric Boat Corporation
  - Numerous Sub-Contractors

A Contractors Perspective

Ricky Milnarik
Electric Boat Engineering Specialist

Electric Boat Corporation

Electric Boat has been building submarines for the U. S. Navy for over 100 years.

In 1900 Electric Boat delivered the U. S. Navy's first submarine, the USS Holland.

Integrated Product and Process Development (IPPD)

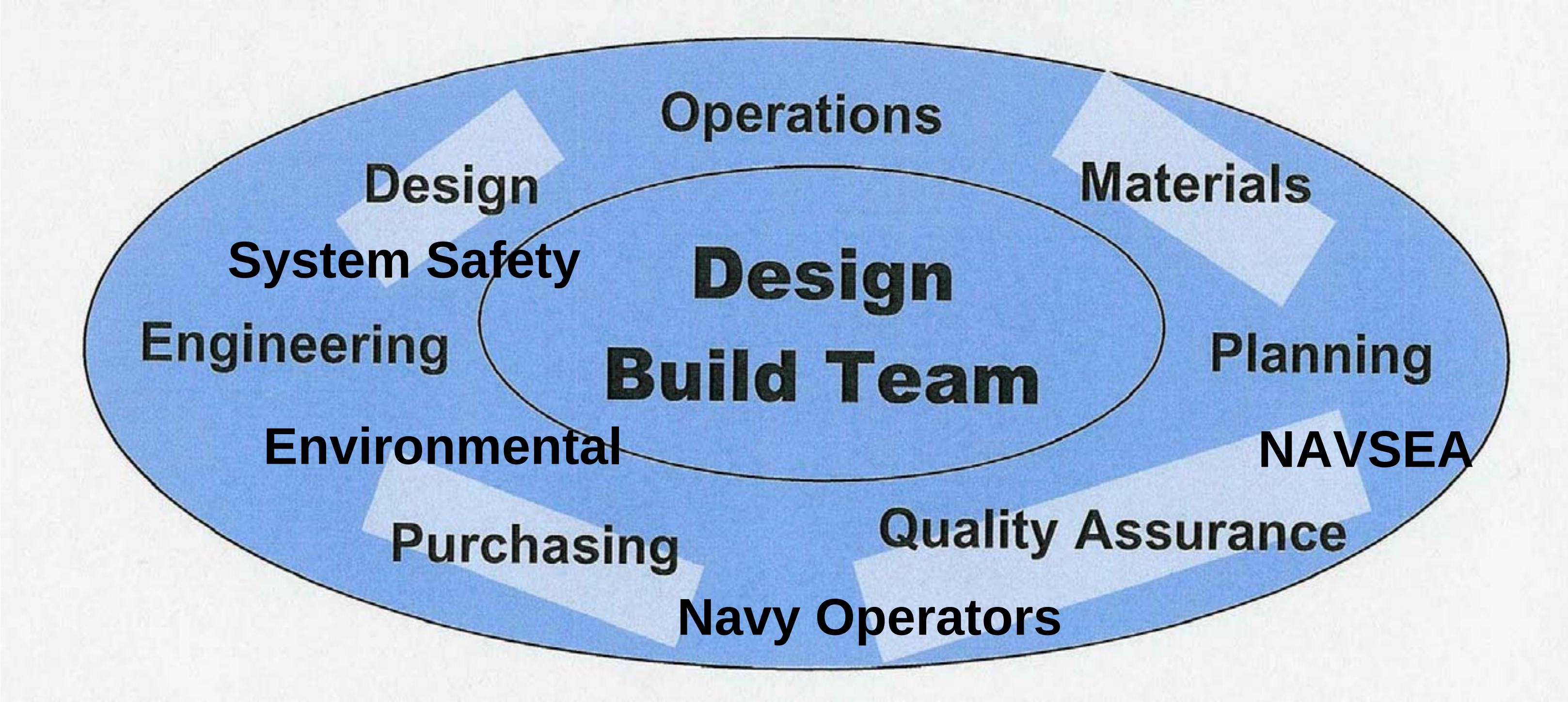
- First used at Electric Boat extensively on the VIRGINIA Class Submarine program in 1994
- Before the IPPD process, a serial approach to submarine design-to-construction was taken.
- The dynamics of the IPPD process is made possible through the use of the Computer Aided Three-Dimensional Interactive Application (CATIA) software design tool to develop electronic mockups.

Integrated Product and Process Development (IPPD)

- Methodology consists of activity-based product management and concurrent engineering Design Build Teams (DBTs).
- Team assignments are structured in accordance with program development and manufacturing needs.

Design / Build Teams

A typical DBT makeup is shown below

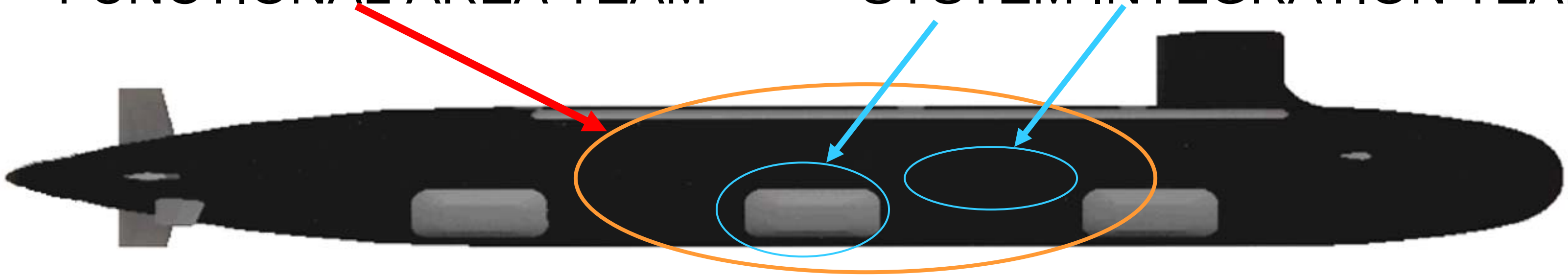


Design / Build Teams

DBT functional managers / technical leaders have direct management and control of their specific functional areas.

FUNCTIONAL AREA TEAM

SYSTEM INTEGRATION TEAMS



Before SSGN !

- Prior to SSGN, System Safety Engineering and Environmental Engineering groups at Electric Boat were not merged into a single Environmental, Safety, and Occupational Health (ESOH) group.
- System Safety and Environmental Engineering were separate parallel processes.
- System Safety and Environmental engineers were in separate locations 7 miles apart.

Before SSGN !

In support of the VIRGINIA Class IPPD process:

- System Safety Engineering conducted traditional MIL-STD-882 hazard analysis reports on identified ship systems.
- Environmental Engineering conducted Design/Build Environmental Analyses (DBEA) on identified ship systems.

SEPARATE PARALLEL PROCESSES

Before SSGN !

- System Safety Engineering identified potential hazards.
- Environmental Engineering identified potential environmental impacts.

SEPARATE PARALLEL PROCESSES

Before SSGN !

- System Safety Engineering tracked hazards in an Hazard Tracking List database.
- Environmental Engineering tracked environmental impacts in a DBEA database.

SEPARATE PARALLEL PROCESSES

SSGN Conversion

- In 2001 the SSGN Conversion Program provided an opportunity to eliminate duplication and integrate System Safety and Environmental Engineering into an effective ESOH group
- Leveraging off the lessons learned from the VIRGINIA (SSN 774) Class Submarine Safety and Environmental programs, the SSGN Conversion program allowed Electric Boat to implement an ESOH program per DODI 5000.2

SSGN Conversion ESOH

A single integrated ESOH Program Plan was developed. Key features included:

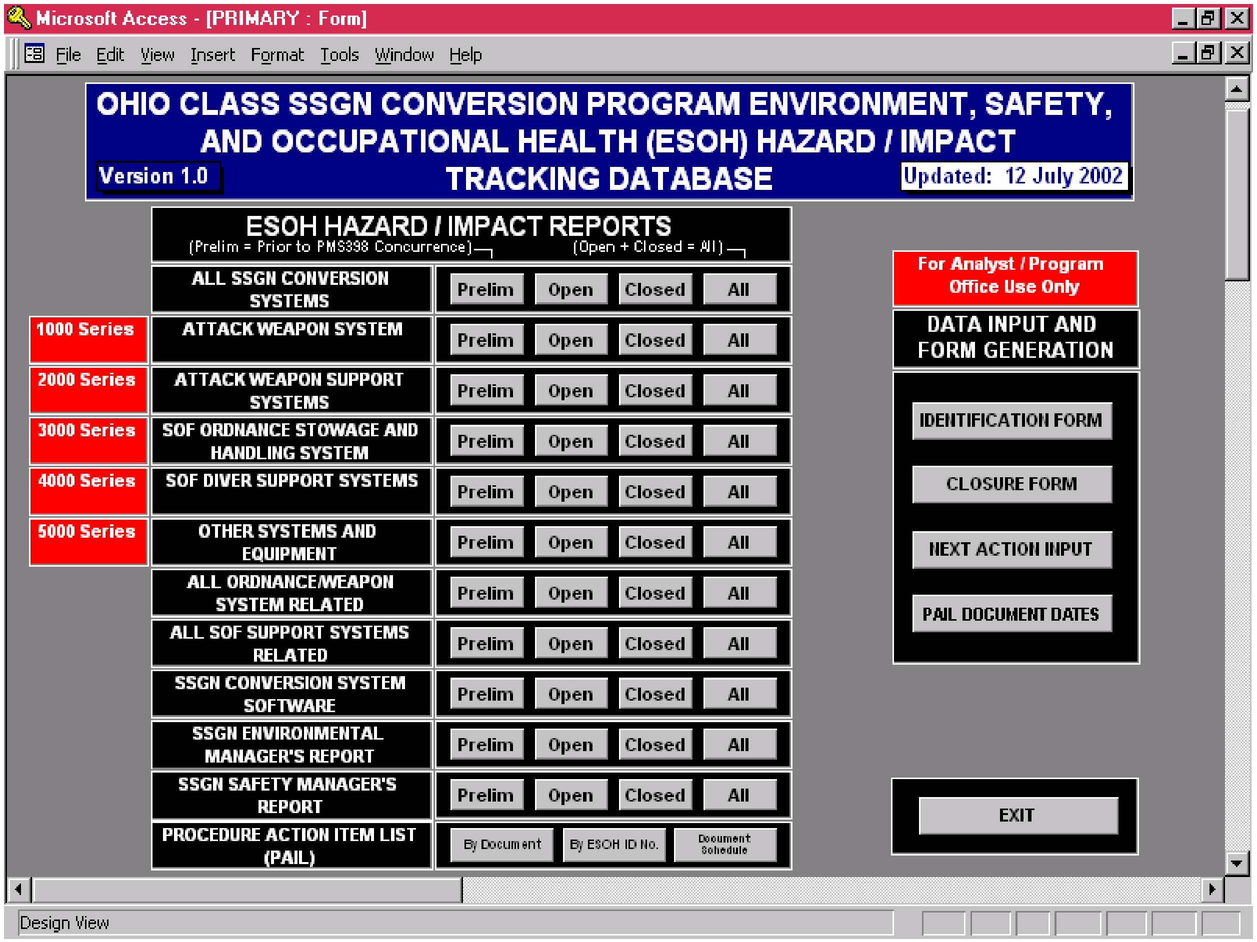
- Making ESOH the responsibility of the DBT.
- Integrating experienced Safety & Environmental engineers into DBTs.
- Define the ESOH hazard analyses for all Electric Boat SSGN Conversion cognizant systems.
- Establish an audit trail of identified ESOH issues (safety hazards/environmental impacts).

SSGN Conversion ESOH

Key features included continued:

- The system safety engineering group was co-located with the environmental engineering group.
- An ESOH Program Integrator was assigned to the program.
- A single report format that would satisfy the needs of both a DBEA and MIL-STD-882 hazard analysis was developed.
- An integrated database was developed to track both system safety hazards and environmental impacts.

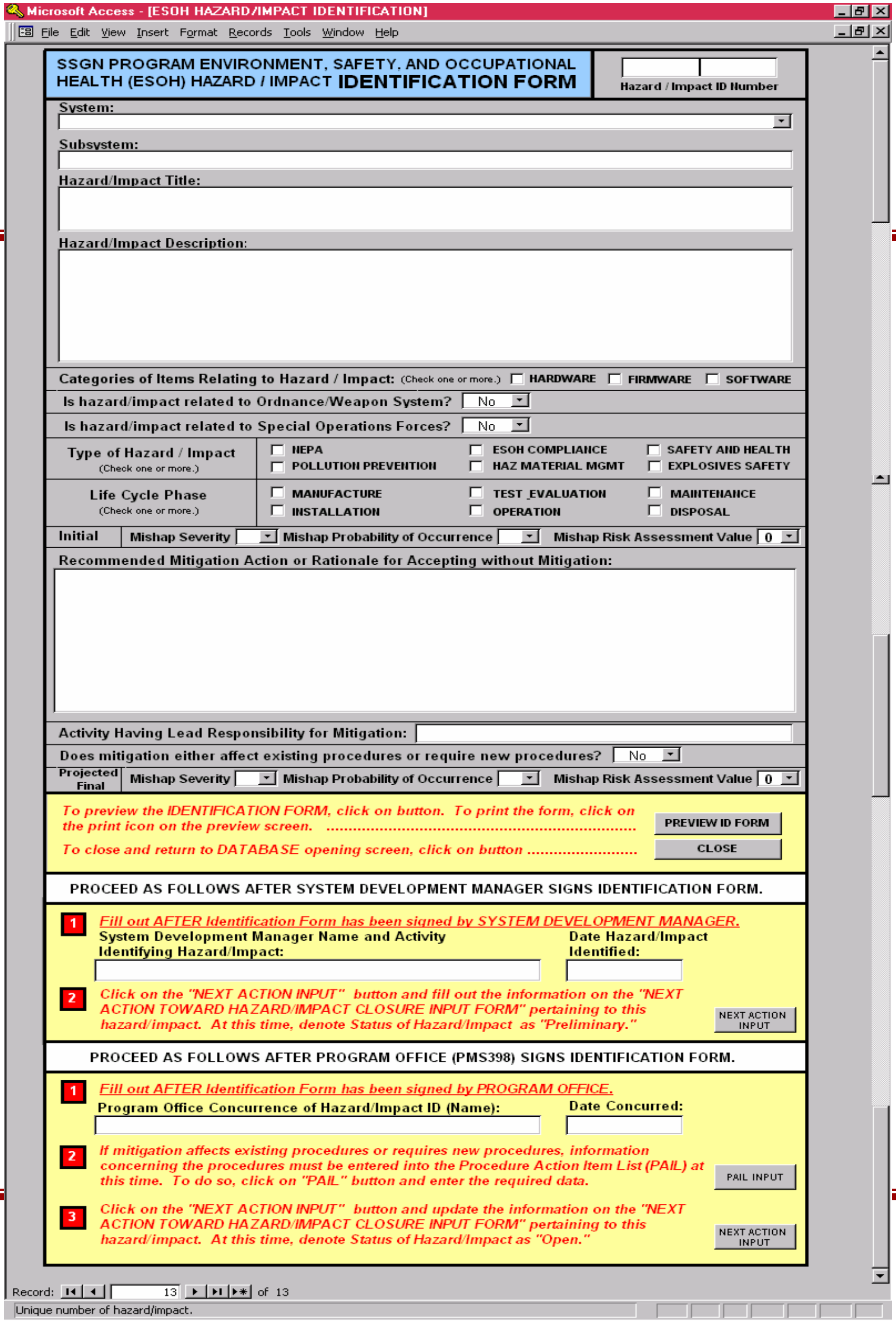
ESOH Hazard / Impact Database



ESOH Hazard / Impact Database

The hazard / impact database is capable of accepting both system safety hazards and environmental impacts on a single unique Hazard/Impact Identification Form.

ESOH Hazard/Impact Identification Form


Microsoft Access - [ESOH HAZARD/IMPACT IDENTIFICATION]

File Edit View Insert Format Records Tools Window Help

SSGN PROGRAM ENVIRONMENT, SAFETY, AND OCCUPATIONAL HEALTH (ESOH) HAZARD / IMPACT **IDENTIFICATION FORM**

Hazard / Impact ID Number

System:

Subsystem:

Hazard/Impact Title:

Hazard/Impact Description:

Categories of Items Relating to Hazard / Impact: (Check one or more.) HARDWARE FIRMWARE SOFTWARE

Is hazard/impact related to Ordnance/Weapon System? No

Is hazard/impact related to Special Operations Forces? No

Type of Hazard / Impact (Check one or more.) — NEPA; ESOH COMPLIANCE; SAFETY AND HEALTH; POLLUTION PREVENTION; HAZ MATERIAL MGMT; EXPLOSIVES SAFETY

Life Cycle Phase (Check one or more.) — MANUFACTURE; TEST EVALUATION; MAINTENANCE; INSTALLATION; OPERATION; DISPOSAL

Initial — Mishap Severity; Mishap Probability of Occurrence; Mishap Risk Assessment Value 0

Recommended Mitigation Action or Rationale for Accepting without Mitigation:

Activity Having Lead Responsibility for Mitigation:

Does mitigation either affect existing procedures or require new procedures? No

Projected Final — Mishap Severity; Mishap Probability of Occurrence; Mishap Risk Assessment Value 0

To preview the IDENTIFICATION FORM, click on button. To print the form, click on the print icon on the preview screen. .... PREVIEW ID FORM

To close and return to DATABASE opening screen, click on button .... CLOSE

PROCEED AS FOLLOWS AFTER SYSTEM DEVELOPMENT MANAGER SIGNS IDENTIFICATION FORM.

1 *Fill out AFTER Identification Form has been signed by SYSTEM DEVELOPMENT MANAGER.*

System Development Manager Name and Activity Identifying Hazard/Impact:

Date Hazard/Impact Identified:

2 *Click on the "NEXT ACTION INPUT" button and fill out the information on the "NEXT ACTION TOWARD HAZARD/IMPACT CLOSURE INPUT FORM" pertaining to this hazard/impact. At this time, denote Status of Hazard/Impact as "Preliminary."* NEXT ACTION INPUT

PROCEED AS FOLLOWS AFTER PROGRAM OFFICE (PMS398) SIGNS IDENTIFICATION FORM.

1 *Fill out AFTER Identification Form has been signed by PROGRAM OFFICE.*

Program Office Concurrence of Hazard/Impact ID (Name):

Date Concurred:

2 *If mitigation affects existing procedures or requires new procedures, information concerning the procedures must be entered into the Procedure Action Item List (PAIL) at this time. To do so, click on "PAIL" button and enter the required data.* PAIL INPUT

3 *Click on the "NEXT ACTION INPUT" button and update the information on the "NEXT ACTION TOWARD HAZARD/IMPACT CLOSURE INPUT FORM" pertaining to this hazard/impact. At this time, denote Status of Hazard/Impact as "Open."* NEXT ACTION INPUT

Record: 13 of 13

Unique number of hazard/impact.

NAVSEA NAVAL SEA SYSTEMS COMMAND

ESOH Hazard / Impact Database

The hazard / impact database can generate and print:

- ESOH Hazard/Impact Identification Forms
- ESOH Hazard/Impact Closure Forms
- ESOH Hazard/Impact Status Reports
- ESOH Program Progress Reports

Additionally, the database has the capability of generating customized reports that satisfy the needs of both the system safety and environmental communities.

Success Recognized

DoN 2006 Special Recognition for Excellence in Safety in the Field of Acquisition

THE SECRETARY OF THE NAVY
WASHINGTON, D.C. 20350-1000

September 6, 2006

MEMORANDUM FOR PROGRAM MANAGER, USS OHIO CLASS SSGN PROGRAM

SUBJECT: Special Recognition for Excellence in Safety in the field of Acquisition

The Department of the Navy 2006 Special Recognition for Excellence in Safety in the Field of Acquisition is presented to the USS OHIO CLASS SSGN Program (PMS398) in recognition of its accomplishments as a leader in promoting acquisition excellence through effective risk management processes and hazard recognition and correction.

In calendar year 2005, the OHIO Class Environmental, Safety, and Occupational Health (ESOH) System Safety Integrated Product Team, including participants from Naval Undersea Warfare Center, Newport Division; General Dynamics, Electric Boat Corporation; and Strategic Systems Programs distinguished itself by providing early identification, elimination, and effective control of system safety hazards and environmental impacts associated with the SSGN Conversion Program.

In 2005 the team closed four Weapons Systems Explosive Safety Review Board (WSERB) findings and completed sixteen analyses and reports in support of a time-compressed program that will provide exceptional capability to the Fleet. In recognition of their exemplary performance the team was nominated for the prestigious David Packard Excellence in Acquisition Award in the category of supporting Secretary of Defense goals, including safety. Accomplishments include:

- Making Safety the responsibility of the design/build teams to ensure application of cognizant engineering expertise;
- Integrating experienced safety and environmental engineers into the design/build teams to add the element of objectivity into hazard analyses;
- Defining applicable safety hazards and environmental impacts and defining and the methods of elimination or mitigation used for resolution; and
- Incorporating SSBN experienced engineers into the design/build teams to identify and resolve any existing safety issues and to implement methods of mitigation in the design and manufacturing of the SSGN.

The USS OHIO CLASS SSGN Program established itself as a leader in making safety an integral part of its organizational culture, and its accomplishments are in keeping with the Department of the Navy's goals and objectives for professional excellence.

Congratulations on a job well done!

Donald C. Winter

"The program emphasizes the integration of safety and environmental engineers into the design/build teams to add the element of objectivity into hazard analyses. This team exemplifies the benefits of the early integration of safety concerns into the acquisition process."

NAVSEA
NAVAL SEA SYSTEMS COMMAND

GENERAL DYNAMICS
Electric Boat

Program Support Review Deep Dive

Pete Nolte

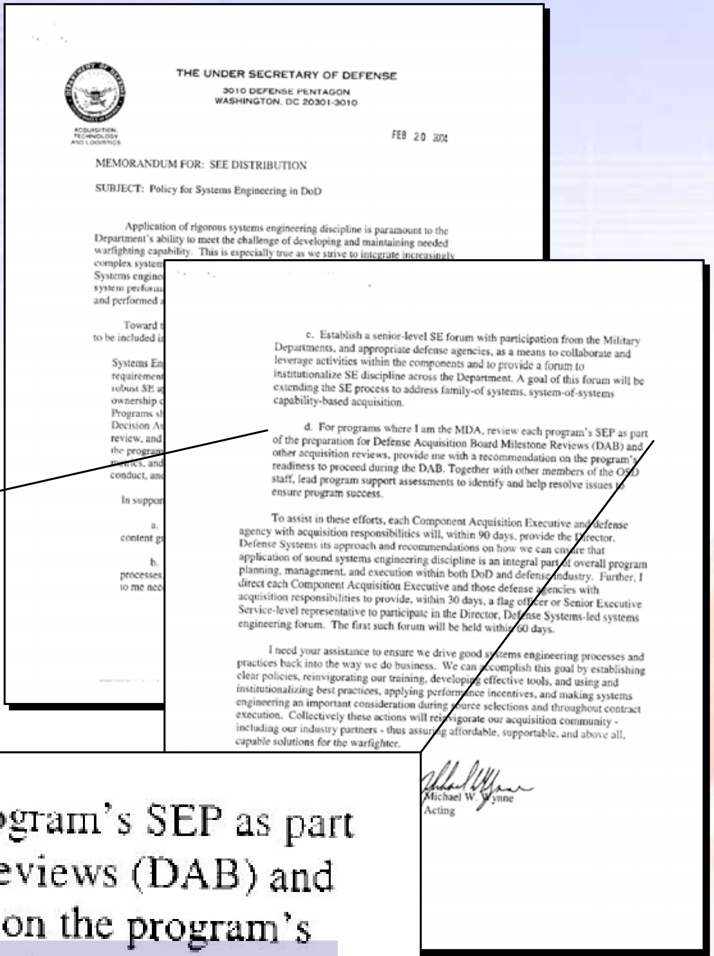
Systems and Software Engineering
Office of the Under Secretary of Defense
for Acquisition and Technology

October 2007

What Are Program Support Reviews?

<u>USD(AT&L) Imperatives</u>:

- “Provide a context within which I can make decisions about individual programs.”
- “Achieve credibility and effectiveness in the acquisition and logistics support processes.”
- “Help drive good systems engineering practices back into the way we do business.”



d. For programs where I am the MDA, review each program’s SEP as part of the preparation for Defense Acquisition Board Milestone Reviews (DAB) and other acquisition reviews, provide me with a recommendation on the program’s readiness to proceed during the DAB. Together with other members of the OSD staff, lead program support assessments to identify and help resolve issues to ensure program success.

Systems and Software Engineering

Assessments & Support

DEPUTY DIRECTOR, ASSESSMENT & SUPPORT

Mr. David Castellano

Glynn James

Suzette Manduley

Infrastructure Support

Ryan Sinclair
Michelle Grillo
Beth Bernat (P/T)
Laura Dwinnell (P/T)
Sarah Rogers (P/T)

Matrix

Mike Cribbs
Lisa Reuss
Dave Gallagher
Spiros Pallas
Don Gantzer
Rich Taylor
Christine Hines
Peter Tabbagh
Jim Bachand
Mike Zsak
Donna Carey
Tom Parry
Chris Powel l

Land Combat

Pete Nolte

John Mercer
John Quackenbush
Jim Waldeck (P/T)
Steve Cox

Fixed Wing Aircraft

Jim Thompson

Bob Darwin
Scott Menser
Nicole Bratt
Bob MacMullin
Joe D'Ambra

Business

Howard Sterling

Roger Kammerdeiner
Steve Hancock

C2ISR

Ray Shanahan (Acting)

Don Maziarz
Dick Overmyer

Rotary Wing & UAS

Jim Schultz

Dick Scott
Kevin Wilcutt
James Alexander
Gregory Carswell

Communications

Ken Hong Fong

Regi Chikar
Jim Wright
Chuck Johnson
Steve Raphael

Subs & Ships

Darren Piccirillo

Mike Wagner
John Clifford

Missiles

Susan van der Veer

Doc Holiday
Gerry Mello

General Review Areas

ASSESSMENT METHODOLOGY FOR PRE-MILESTONE C

ASSESSMENT METHODOLOGY FOR PRE-MILESTONE B

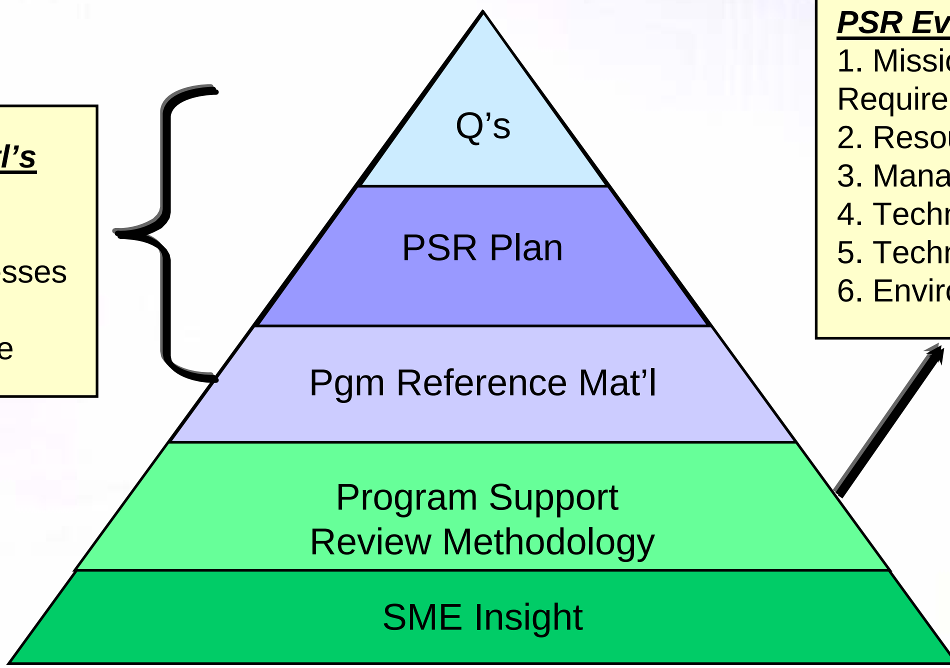
ASSESSMENT METHODOLOGY FOR PRE-MILESTONE A

http://www.acq.osd.mil/sse

Program Support Review (PSR)

- DAPS; a repeatable, tailorable, exportable process
- Trained workforce with understanding of program issues

PSR Reference Matl's
- Templates
- Sample Questions
- Documented Processes
- Training Materials
- Execution Guidance



PSR Evaluation Areas
1. Mission Capabilities/ Requirements
2. Resources
3. Management
4. Technical Process
5. Technical Product
6. Environment

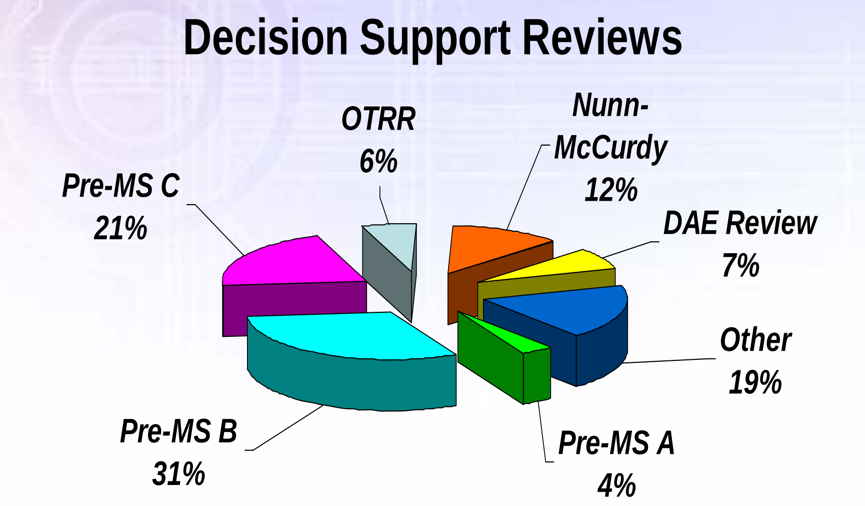
"…PSR team serves as 'disinterested 3rd party' that allows [the PM] to approach leadership armed with powerful program truths, reinforce issues." (PM)

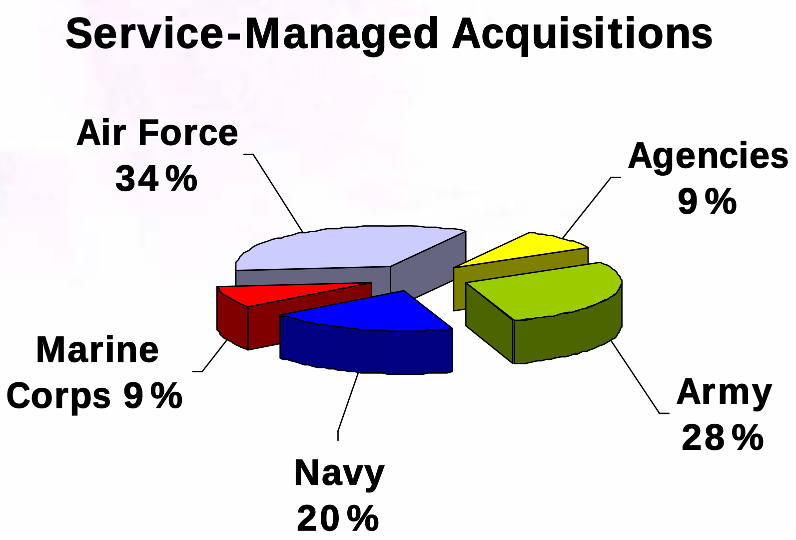
PMs Report Process is Insightful, Valuable, and Results Oriented; better than 95% acceptance of recommendations

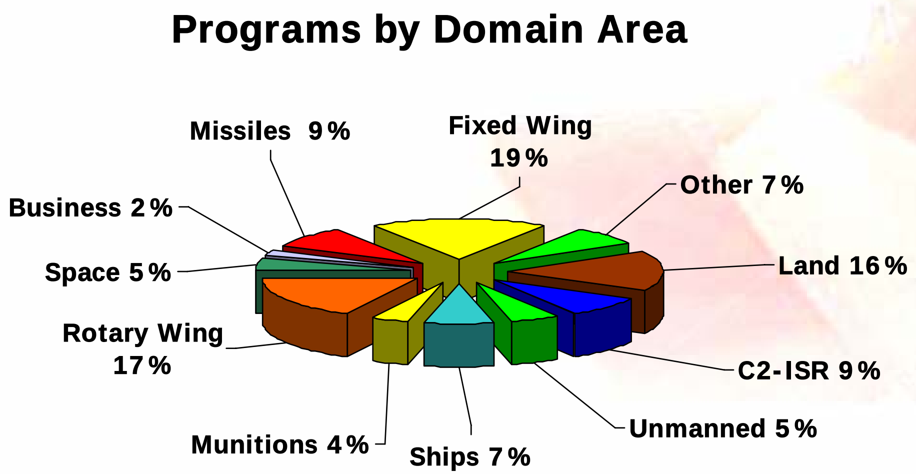
Program Support Review Activity

(since March 2004)

- PSRs/NARs completed: 48
- AOTRs completed: 11
- Nunn-McCurdy Certification: 10
- Participation on Service-led IRTs: 2
- Technical Reviews: 10
- Reviews planned for FY07:
  - PSRs/NARs: 8
  - AOTRs: 1

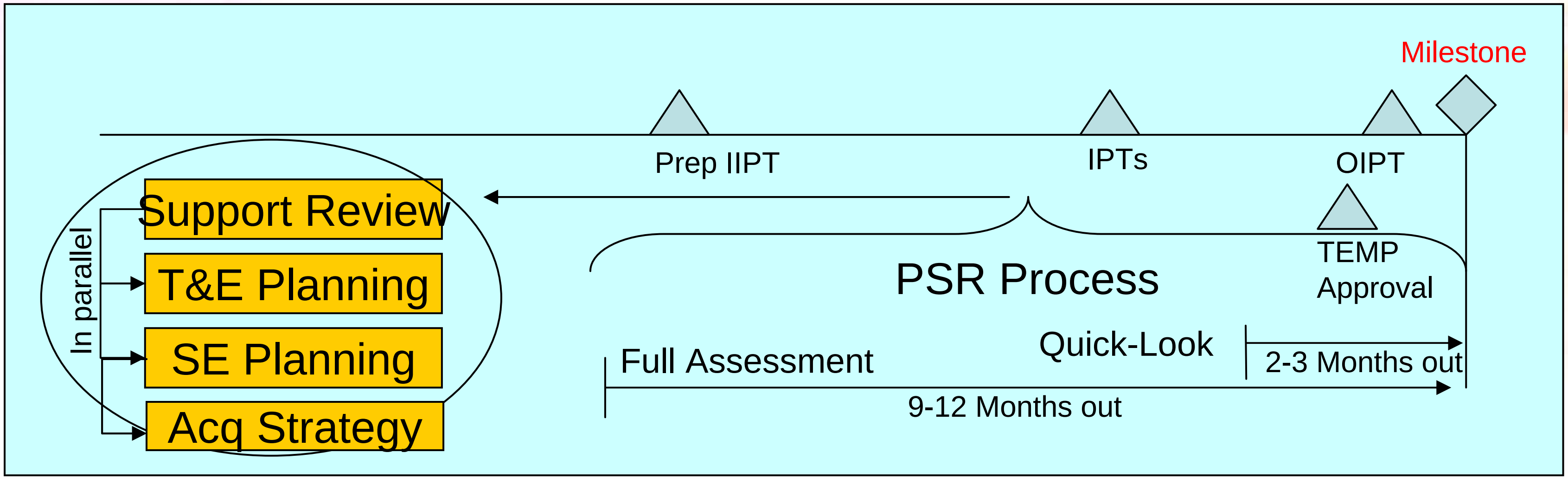






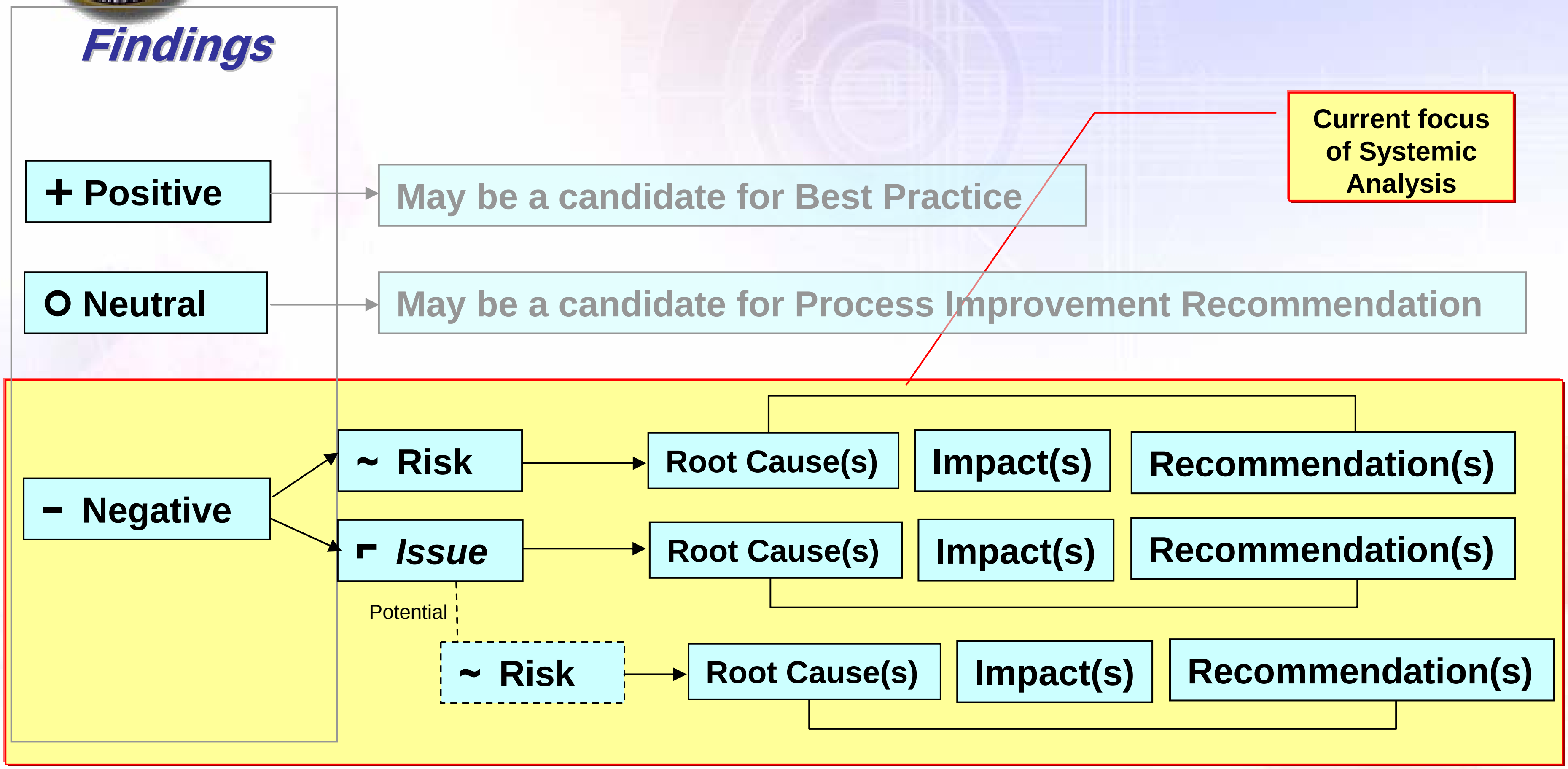
General Approach: Review Products

- The Team's top-level products:
  - Full reviews conducted 9-12 months before Milestone
    - » Detailed findings, risks & actionable recommendations
    - » Conducted in "PM support" vice "OSD oversight" mode
  - "Quick-Look" reviews conducted 2-3 months before Milestone
    - » Same form and formats; Conducted "for record" review
  - Quarterly Defense Acquisition Executive Summary assessments
  - Test & Evaluation Master Plan (TEMP) and Systems Engineering Plan (SEP) development and approval

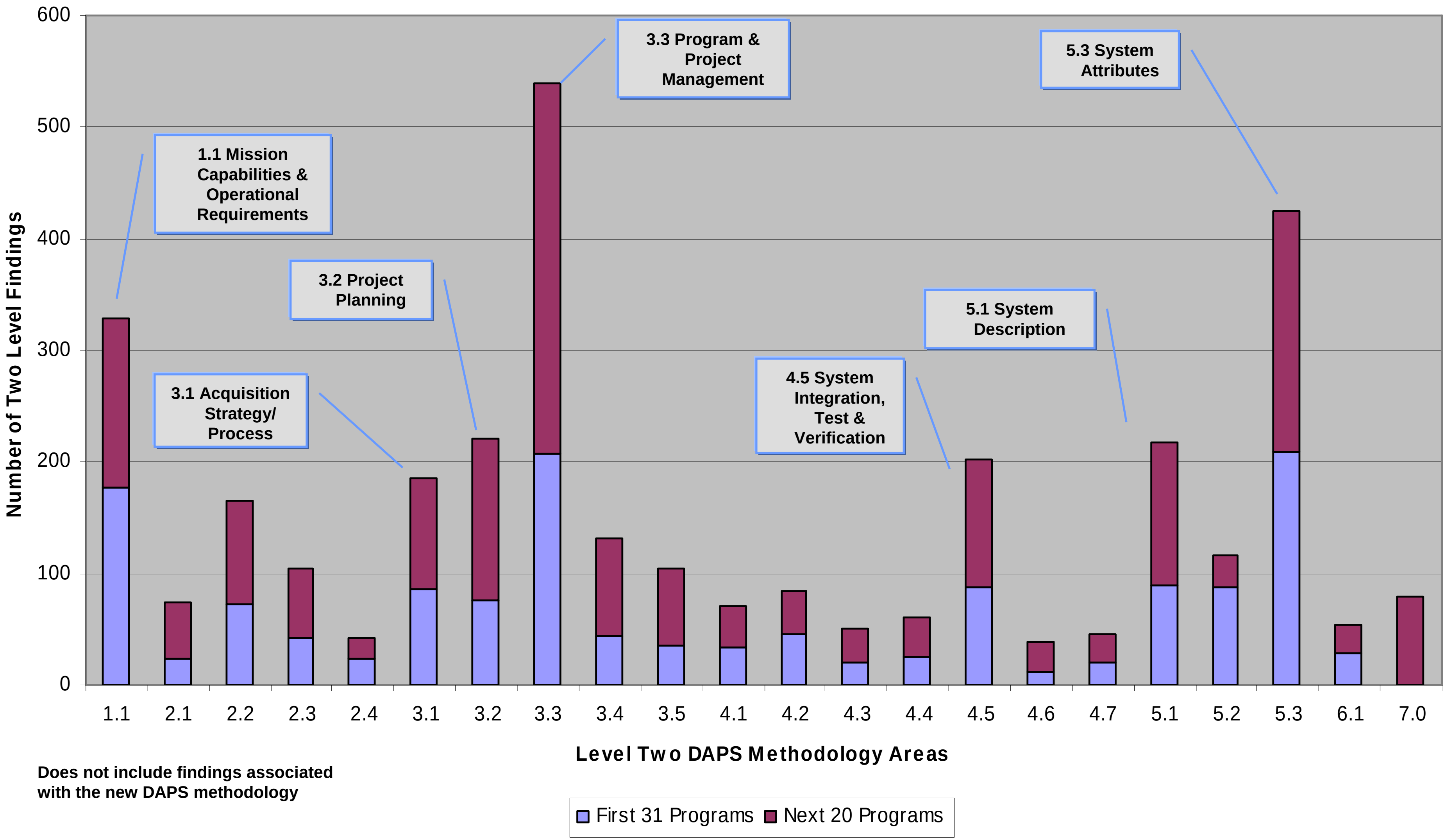


Program Support Review
Taxonomy of Classifications

+ Positive
O Neutral
− Negative
⌜ Issue
~ Risk



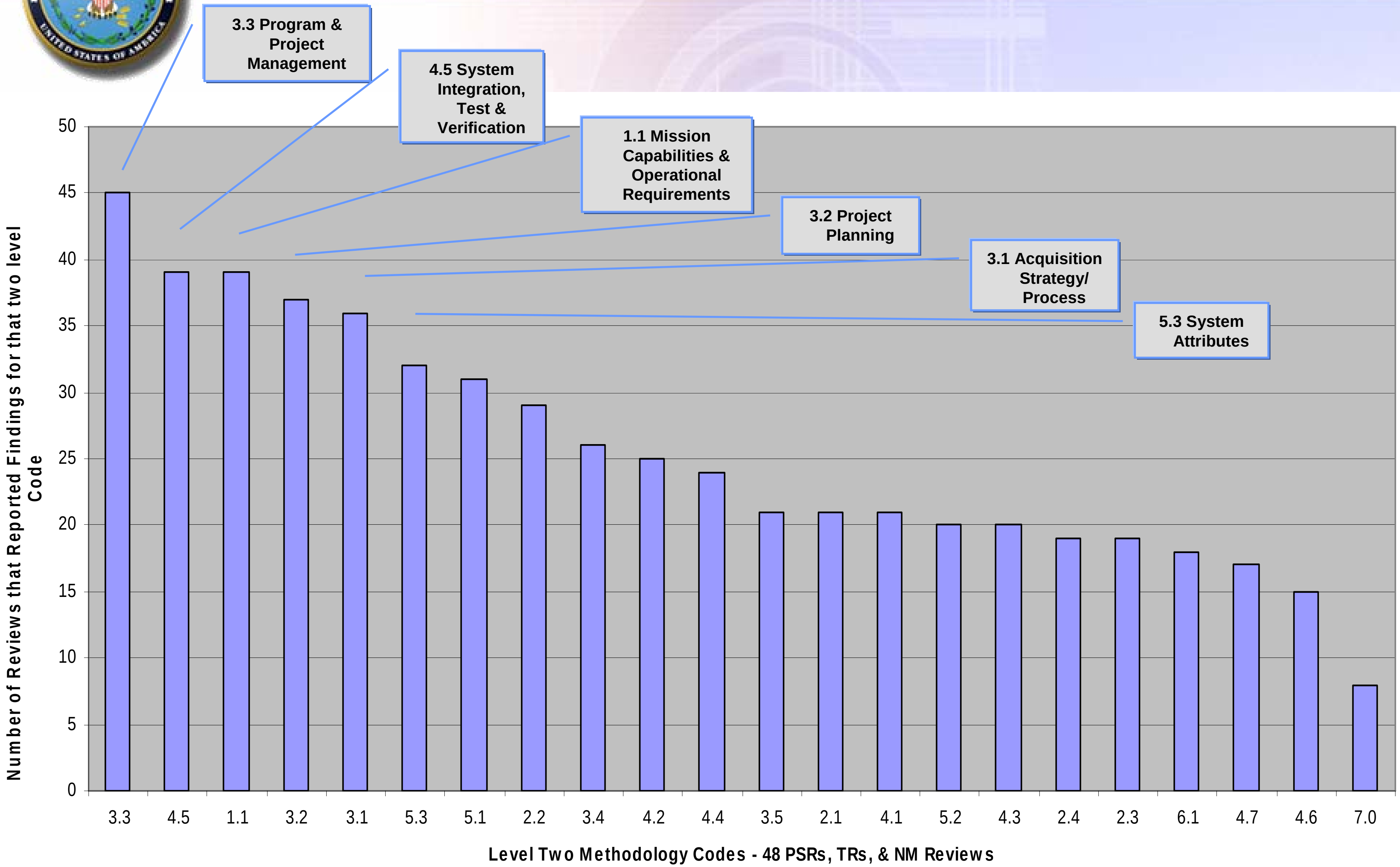
Program Support Review Findings
(March 2004 Through September 2007)



Does not include findings associated with the new DAPS methodology

Program Support Review Findings

(March 2004 Through September 2007)



Representative PSR Findings (1 of 3)

1.1 Mission Capabilities/Requirements

– Lack of reasonable, measurable, and testable requirements
– Requirements refer to “predecessor” systems
– Requirements changes contribute to SE churn
– Lingering requirements issues have increased program costs and risks
– Failure to establish a process for flowing down requirements
– Requirements are not fully understood after contract award
– Lack of growth margins/trade-space

3.1 Acquisition Strategy/Process

– Resistance to demonstrate key functionality by MS C
– Balance between requirements, schedule and resources
– Acquisition strategy doesn’t address key issues

Representative PSR Findings (2 of 3)

3.2 Project Planning

- Schedule vs. event driven programs
- No “time” to conduct the full suite of SE technical reviews
- Lack of Integrated Master Plan/Integrated Master Schedule
- Underestimation of integration efforts and COTS modifications
- Lack of meaningful acquisition phase exit criteria

3.3 Program & Project Management

- Marginal Program Office staffing; Difficult to retain high quality personnel
- Roles, responsibilities, and lines of authority are not clear
- Poor communication across IPTs and program lines
- Lack of management metrics to monitor program health
- EVMS does not provide insight and does not reflect work being done
- Lack of properly documented risks and mitigation plans

Representative PSR Findings (3 of 3)

4.5 System Integration, Test, & Verification

- Highly concurrent test schedules; Success-oriented
- Aggressive schedule lacks adequate time for corrective actions
- Optimistic plans to leverage M&S; Lack of VV&A planning
- Shortage of military operators for operational tests
- Testing and verification approach are inadequate
- Developmental testing not complete prior to IOT&E

5.3 System Attributes

- Insufficient efforts to design-in reliability and maintainability, including diagnostics
- Weak emphasis on suitability contributes to IOT&E issues
- Late production planning; Insufficient Production Readiness Reviews
- Challenging production ramp rates for contractors/suppliers
- Optimistic software productivity, reuse and growth estimates

Thoughts That Need Reinforcement (1 of 3)

- Mission Capabilities/Requirements
  - Ensure CDD/CPD requirements are reasonable, measurable and testable
  - Ensure approved CONOPS informs requirements generation process
  - Maintain stable requirements
  - Conduct cost/performance trades with PM, user and contractors
  - Push high risk requirements to the next increment
  - Conduct SRR in TD phase with contractors
  - Understand COTS/GOTS capabilities and limitations (when operated in a military environment)
  - Be aware of critical dependence on external programs with developmental issues
  - Establish space/weight/power/cooling margins
- Management
  - Balance requirements, resources and acquisition strategy
  - Plan to demonstrate key functionality in SDD phase
  - Maintain event driven schedules; establish entry/exit criteria
  - Use earned value management as a vehicle for planning, executing, and controlling the program
  - Employ a robust risk management process and resource mitigation activities

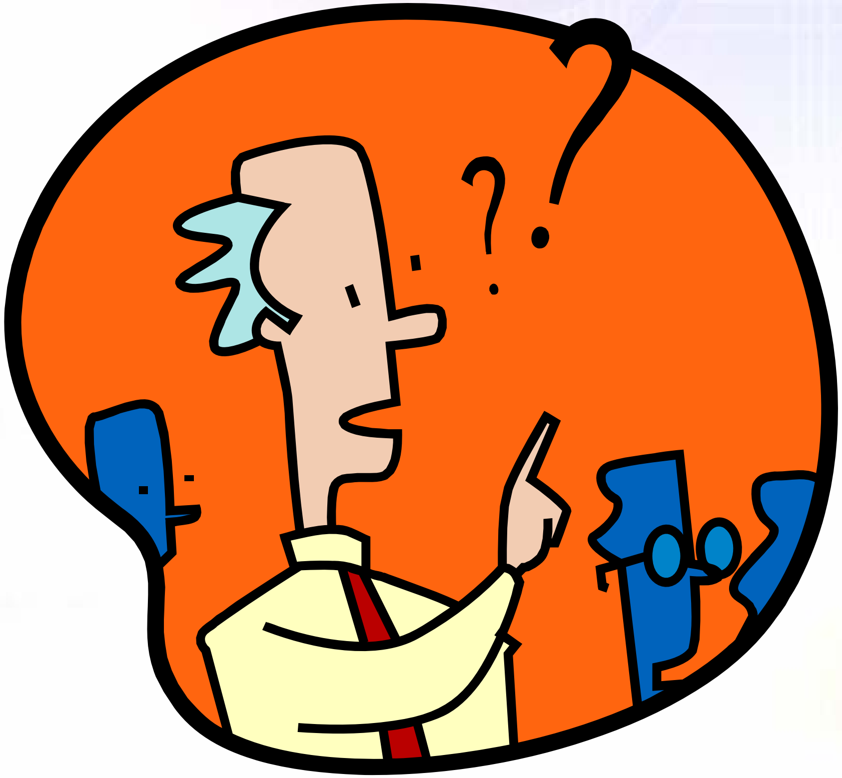
Thoughts That Need Reinforcement (2 of 3)

- Management (cont.)
  - Ensure communication between IPTs; and with Contractor
  - Define IPT roles, responsibilities, authority and conflict resolution process
  - Manage external interfaces; establish issue resolution process
  - Avoid urgency of need outweighing good engineering and program management
- Resources
  - Ensure funding is properly phased and adequate to support planned SE activities
  - Adequately staff the program with qualified personnel
  - Ensure early selection of M&S and plan to VV&A planning
  - Ensure adequate management reserve
- Technical Product
  - Use mature technologies and modular open architecture
  - Assess COTS/GOTS form factor changes and integration challenges
  - Plan to design-in reliability and maintainability
  - Assess supportability in the SDD phase
  - Provide early focus on production planning
  - Use realistic software size, productivity, and reuse estimates
  - Ensure test schedule reflects adequate time for corrective actions and reporting

Thoughts That Need Reinforcement (3 of 3)

- Technical Process
  - Use established SE processes
    - Full suite of SE technical reviews
    - Independent chairman and SMEs
    - Adequate time between technical reviews/SDD events
    - Maintain technical baselines
    - Process compliance
  - Ensure translation of operational requirements into contractual language
  - Comprehensive contractual verification (section 4 of spec) of meeting requirements (section 3 of spec)
  - Ensure adequate requirements flow-down/ traceability/ decomposition
  - Put emphasis on test and verification approach
- Environment
  - Ensure consistency in program documentation
  - Be aware of new policies, Congressional language, and certifications

Questions…perhaps Answers



Back-up Slides

Samples of Program Support Review Positive Observations

- Experienced and dedicated program office teams
- Strong teaming between PM offices and contractors
- Use of well defined and disciplined SE processes
- Proactive use of independent review teams
- Successful management of external interfaces
- Corporate commitment to process improvement
- Notable manufacturing processes
- Appropriate focus on performance-based logistics
- Focus on DoD initiatives
- Excellent risk management practices

But not on all Programs…